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EDITORIAL.

THE U.S.S. ARMORED FRIGATE NEW IRONSIDES.

THIS vessel, famous in naval history as our first successful sea-going iron-clad steamer, as well as for the service she performed in the great rebellion, was destroyed by fire, in the League Island channel, near this city, on the 16th of December last.

We believe that, outside of official documents, no authentic record exists of her dimensions and peculiar features, nor of the history of her inception and construction. We have therefore obtained, and propose to place before our readers, the prominent and most interesting facts relating to her.

The subject of plating vessels of war had, notwithstanding the building of certain French and English iron-clad vessels, received but little attention in this country prior to the middle of the year 1861. During the first months of the war, the Navy Department was too busily engaged in obtaining a respectable fleet of vessels of offence, to think much of rendering them invulnerable to attack. Nor was it at that time generally realized, how soon the necessity would arise for vessels capable of resisting heavy shot, or how important such powers of resistance might prove to be.

To Admiral Joseph Smith, then (and still) at the head of the Bureau of Yards and Docks, in the Navy Department, we are, as a nation, most indebted for the first outlook in this direction. He had the sagacity to perceive and the ability to urge successfully upon the Department the importance of taking such action as would elicit the ideas of practical ship and machinery builders, in regard to the best mode of combining within one hull, the power of flotation in shallow water, with powers of offence, defence and locomotion by steam.

On the 8th of August, 1861, a commission was appointed by the Honorable Secretary of the Navy, under authority of an act of Congress, approved August 3d, 1861, to investigate plans and specifications, and to obtain proposals for, the construction of armored vessels; to compare these plans, decide on their relative merits and recommend to the Secretary the award of contracts on preferred plans; the aggregate value of which plans should not exceed $1,500,000.

This Commission was, with great propriety, made to consist of Admirals (then Commodores) Joseph Smith and Hiram Paulding, and Admiral (then Commander) C. H. Davis.

In pursuance of their duties, the Commission received proposals for seventeen different plans of vessels.

Of these plans only three were considered feasible as combining the proper qualifications; which had been defined in the following advertisement issued August 7th, 1861:

"IRON-CLAD STEAM VESSELS."

"The Navy Department will receive offers from parties who are able to execute work of this kind, and who are engaged in it, of which they will furnish evidence with their offer, for the construction of one or more iron-clad steam vessels of war, either of iron or of wood and iron combined, for sea or river service, to be not less than ten nor over sixteen feet draught of water, to carry an armament of from eighty to one hundred and twenty tons weight, with provisions and stores for from one hundred and sixty-five to three hundred persons, according to armament, for sixty days, with coal for eight days. The smaller draught of water compatible, with other requisites, will be preferred. The vessel to be rigged with two masts, with wire rope standing rigging, to navigate at sea.

"A general description and drawings of the vessel, armor and machinery, such as the work can be executed from, will be required.

"The offer must state the cost and the time for completing the whole,

exclusive of armament and stores of all kinds, the rate of speed proposed, and must be accompanied by a guarantee for the proper execution of the contract, if awarded.

"Persons who intend to offer are requested to inform the Department of their intention before the 15th August, instant, and to have their proposition presented within twenty-five days from this date."

In accordance with the award of the Commission, contracts were entered into with the three following parties, under guarantee to perform all that they agreed on, viz:

1st. Bushnell & Co., New Haven, Connecticut; price $235,250. Vessel of wood, and of rounded shape, to carry a broadside battery, and to be clad with iron bars of peculiar construction. Draught of water, ten feet; length, one hundred and eighty feet; breadth, thirty-two feet; depth, twelve and two-thirds feet.*

2d. Merrick & Sons, of this city, well known as the builders of the machinery of many of the naval vessels then afloat; price, $780,000. Vessel of wood, with sides sloping inward above water-line, clad with four and a half inch armor in solid plates; to carry a broadside battery. Draught of water, fourteen feet; displacement, three thousand three hundred tons.

This vessel was the *New Ironsides*, a full description of which will be given below.

3d. Captain John Ericsson, of New York; price, $275,000. Vessel of iron, having projecting guards below and above the water-line, deck very low, surmounted by revolving turret for two guns. Plate-laminated armor and turrets. Length, one hundred and seventy-two feet; breadth on deck, forty-one feet; depth, eleven and a half feet; displacement, twelve hundred and fifty-five tons.†

The designers of the *New Ironsides* adopted the thickness and general size of iron plates then used in foreign navies, and formed the sides of the vessel on an angle, as in the French ship *La Gloire*. But they were obliged in other respects, from the very light draught of water to which they were restricted, to strike out a new path; for it should be borne in mind that in many important respects the light draught vessel labors under disadvantage as compared with that of deep draught.

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* This vessel was the *Galena*. Her armor was found too light for service, although as heavy as could be carried with her light displacement.

† This was the original *Monitor*, the type of all of the armored vessels afterwards built.

1st. Her lines must be more full (other things being equal), and hence more difficult of propulsion and of manageability.

2dly. Her screw must be smaller, and therefore less effective as an instrument of propulsion.

3dly. Her hull must be more strengthened owing to lack of depth, and must, therefore, be heavier to possess the same power of resistance to the action of the sea, and, in the case of armored vessels, to the weight of the armor.

The dimensions adopted were as follows:

HULL.

	Feet.	Inches.
Length over all	249	6
" on load-line	242	2
" between perpendiculars	230	0
Beam, moulded	55	9
" over planking	56	7
" " plating (4½ inches)	57	4
" " " at spar-deck	46	2
Depth to plank-shear above base-line	26	7
" top of rail " "	29	3
" upper port-sill " "	24	2
Load-line above base-line	14	5
" " " bottom of keel	15	0
Timber frames at throats, moulded	1	6
" " turn of bilge "	1	1
" " vertical sides "	0	9
" " spar-deck "	0	7
Solid from stem to stern.		
Planking on floor	0	5
" increasing to lower edge of plating to	0	9½
" recessed for lower tier " "	0	6½
" thence to plank-shear	0	5
Ceiling from turn of bilge to spar-deck	0	8
Water-ways very heavy, especially at lower deck close to load-line.		

ARMOR.

	Feet.	Inches.
Plating begins below load-line	4	0
Width of the lower tier	2	4
Thickness " "	0	3
Above which it was	0	4½

This plating extended completely round the vessel, from four feet below load-line to three feet above it, terminating forward in a ram four and a half feet deep and nine inches thick, which projected six feet from the stem. Above the upper edge of this plating, which terminated the vertical sides amid-ships, the sides began to "batter" in-

ward, falling back five feet seven inches in a height of ten feet; the plating covered these sides for a length of one hundred and seventy feet and was carried flush with top of plank-shear water-ways. The spar-deck beams were covered with one-inch iron plating and this with four inch plank; all hatches were protected with gratings composed of bars six inches by one inch on edge, held one and a half inches apart by thimbles, and the whole held together by bolts through thimbles and bars.

There were three decks, the lower or berth-deck being cut through for engines and boilers.

The plating was secured by galvanized iron wood screws, having countersunk heads, slotted for a screw-driver wrench; the inner sides of the plating were protected from corrosion by contact with the wood by caoutchouc paint, and a thick caulking of the same was paid into the ledge seam under the lower tier of plating, to protect it from the galvanic action which would have resulted from contact with the copper sheathing.

The plating was grooved on edges, sides and ends, and square tongue-rods of iron, one by one and a half inches, laid in to break the joint.

Heavy timber bulkheads between the berth and gun-deck, and between the gun and spar-decks, extended across the vessel, both forward and aft, the distance between them being one hundred and sixty-three and a half feet, or somewhat less than the length of the outside plating. These bulkheads above the gun-deck were covered with diagonally laid iron bars, two inches thick, in two thicknesses, one overlaying the other. Outside of these bulkheads, on the gun-deck aft, was the captain's quarters, and forward was the sick bay.

In each bulkhead was a door of five-inch solid plate, sliding on rollers movable by rack and pinion.

These bulkheads enclosed the gun-deck, and proved an effectual barrier to raking fire.

MACHINERY.

The motive machinery consisted of four horizontal fire-tube boilers of seventeen feet front, and six furnaces each, giving a collective grate area of three hundred and fifty-six square feet, and of heating surface eight thousand seven hundred and seventy-six square feet. Coal was carried in hanging bunkers over the boilers as well as below the berth-deck.

The engines were two horizontal direct-acting, of fifty-inch cylinders,

thirty inches stroke, having surface condenser, and driving a four-bladed screw thirteen feet diameter, twenty feet pitch. Small as it was for a ship of three thousand five hundred tons displacement, it was as large as could be got in, owing to the massive projecting counter, the lower edge of which was two feet under water, and which carried the weight of the stern plating. At a speed of sixty revolutions (which could readily be maintained) the ship could be driven at eight and a half knots (nautical miles) per hour in still water.

The coal carried was three hundred tons, which would last for nine days full steaming.

BATTERY.

The ship was originally designed to carry a battery of sixteen nine-inch Dahlgren guns, and a crew of one hundred and sixty-five men to work it. But after launching, it was found that there was such a superabundance of buoyancy provided in the hull, as to permit the battery to be increased to fourteen eleven-inch Dahlgren guns and two two hundred-pounder Parrott rifle guns, with crew for the same of four hundred and fifty men, without making the load-draught greater than had been stipulated.

This fortunate circumstance, resulting from an excessive caution on the part of the builders, proved to be of the first importance in the subsequent history of the ship, increasing very greatly her offensive powers, although at the same time it prevented the attainment of the stipulated rate of speed, the calculation for which had been based on a reduced displacement.

The additional weight carried over that provided for in the contract was five hundred and fifty tons.

The load-draught, with full coal and stores, was, in salt water, fifteen feet above bottom of keel.

The weights carried were as follows:

	Pounds.
Weight of deck armor	350,000
" " side armor and port-shutters	1,450,000
Total weight of armor	1,800,000
Weight of machinery	730,000
" " water in boilers	150,000
Total weight of machinery	880,000
Weight of ordnance, carriages and ordnance stores	898,000
" " provisions, clothing and small stores	233,000
Total weight ordnance and stores	1,131,000

Such is a concise description of the *New Ironsides*. She was contracted for October 15th, 1861, launched May 15th, 1862, and sent to sea complete August 21st, 1862, in ten months after date of contract. It is believed that there are few if any instances on record of a work of such magnitude—good work, too, not slighted in any respect—being done in so short a period. Especially is this despatch remarkable, when we consider the fact that the vessel was an experiment, involving many novelties of construction; that a tremendous pecuniary responsibility rested upon her builders, who had designed the ship, and had guaranteed certain results; and that the eyes of the nation were turned towards her, anxiously awaiting her success. The consciousness of these circumstances, and a knowledge of the great service she might render in subduing the rebellion, would naturally render her builders more cautious in their advance.

We learn from Messrs. Merrick & Sons, her designers and builders, (to whom we are indebted for most of the particulars herein stated,) that the credit of originating the *New Ironsides* is due to their late superintendent, B. H. Bartol, Esq., who also planned the armoring and supervised its fitting on board, and to whom the general supervision of the hull was confided. The wood-work of the hull was built under subcontract with them by Messrs. William Cramp & Sons, of this city.

The armor plating was hammered of the best Pennsylvania charcoal scrap iron, half of it by Bailey, Brown & Co., of Pittsburgh, Pa., and half by the Bristol Forge Co., Bristol, Pa.

The *New Ironsides* proved herself an admirable sea-going vessel, and was, of all the iron-clad vessels in our navy, the especial favorite of officers and men, for her thorough ventilation, her safety in heavy weather and the formidable character of her battery. It is, we think, a subject of great regret to all, that by her destruction our navy has suffered so severe a loss, and especially that the Navy Department has not developed to some extent the ideas presented in her construction by building other similar vessels, improved, as they doubtless would have been, by experience with her. Without entering into a discussion of the question of the relative merits of broadside and of turret battery, it is at least beyond dispute, that for rapid and continuous firing, such as would be required in the reduction of large forts, the broadside battery presents advantages hitherto unattainable by the use of revolving turrets.

Some difficulty was at first experienced in steering, owing to the immense mass of the hull and her very full water-lines, which required

quick meeting with the helm to prevent the vessel taking a sheer. Until the pilot and the men employed in steering became accustomed to this peculiarity, her speed was limited by it. A little experience, however, enabled them to control perfectly the direction given, and her reputation for manageability became established.

Unfortunately, during the harbor attack upon Charleston, April 7th, 1863, the steering of the ship was taken out of the hands of her own pilot; and the ship being in a swift tide-way and very shoal water (eighteen inches more than her draught), some difficulty was experienced in her steering. This having been improperly attributed to the vessel, injured her reputation until the facts became known.

We conclude this account by giving a copy of the record of the firing done by the *New Ironsides* in service at Charleston Harbor. Her armor bore evidence of the severity of the attacks to which it was subjected. Not only was it never perforated, but the deepest indentation was not over half its thickness.

RECORD OF FIRING, &C.

April	6th, 1863.	Crossed the bar—Charleston Harbor.
"	7th, "	Got underweigh 12½ P. M. Came out at 5 P. M. Struck several times and lost a port-shutter. Fired eight shots.
July	18th, "	Commenced 12·15 P. M. Ceased 7·49. Struck ten times. Fired eight hundred and five rounds.
"	20th, "	Commenced 2·8 P. M. Ceased 4·27. Struck thirteen times. Fired one hundred and sixty-eight rounds.
"	24th, "	Opened 5·43. Ceased 9·55. Struck twelve times. Fired two hundred and twenty rounds.
"	29th, "	Opened 12·20 P. M. Ceased 2·45. Struck two times. Fired two hundred and ten rounds.
"	30th, "	Opened 11·32 A. M. Ceased 1·45. Struck three times. Fired three hundred and sixty-six rounds.
Aug.	17th, "	Opened 7 A. M. Ceased 1 P. M. Struck thirty times. Fired four hundred and twenty-eight rounds.
"	18th, "	Opened 8·15. Ceased 9·45. Not struck. Fired one hundred and eighteen rounds.
"	19th, "	Opened 1·50. Ceased 2·25. Not struck. Fired sixty-four rounds.
"	20th, "	Opened 11·20 A. M. with spar-deck rifle, firing twice. 1·20 opened on Fort Wagner. Ceased 3·30 Fired one hundred and fifty-eight rounds.
"	21st, "	Opened 6 P. M. Ceased 7·30. Struck by 11-inch shot in port-bow. Fired one hundred and fourteen rounds.
"	22d, "	Opened 11·40. Ceased 1·45. Fired one hundred and eighty-two rounds.
"	23d, "	Opened 8 A. M. Ceased 9. Struck five times. Fired eighty-eight rounds.

Sept. 2d, 1863.	Opened 1·50 A. M.	Ceased 4·30. Struck seven times. Fired fifty rounds.
" 5th, "	Opened 9·45 A. M.	Ceased 6·35 P. M. Struck fifteen times. Fired five hundred and four rounds.
" 6th, "	Opened 5·15 A. M.	Ceased 6·30 P. M. Struck three times. Fired two hundred and thirty-eight rounds.
" 7th, "	Opened 5·45 P. M.	Ceased 7·15 P. M. Struck fifty times. Fired one hundred and fifty-two rounds.
Oct. 5th, "	Torpedo exploded under starboard side, 9 P.M., mortally wounding by the concussion Acting Master Howard, who died October 10th. But beyond driving a deck-beam on end to shattering a knee, doing no material damage to the ship.	

RECAPITULATION.

Total time in action	68 hours 49 minutes.
" number of rounds	4361.
" " times hit	250.

From the date of her first going into commission, previous to her departure for Fortress Monroe, in August, 1862, and during the earlier part of the siege of Charleston, she was commanded by Com. Thomas Turner. He was relieved by Capt. S. C. Rowan, who remained in command until her return to Philadelphia, in June, 1864. August 1st, 1864, she was placed in charge of Com. Radford, and left Philadelphia September 25th, 1864, for Hampton Roads; in the vicinity of which, making occasional trips in the James River, she remained till December 13th, when she took her departure on the Fort Fisher expedition. January 13th, 14th and 15th, 1865, she was engaged in the famous attack on that fortress. On the 20th instant she returned to Hampton Roads. On March 30th she arrived at the Navy Yard, Philadelphia, and went out of commission for the last time, April 6th, 1865.

PARIS EXPOSITION.

As the time approaches for the opening of the great International Exposition at Paris, some anxiety must be felt by Americans, proud of the resources of their country, as to the extent of its representation as a nation. That it will be fully represented is in no way possible. Its mineral wealth will be shown, and much that is interesting in connection with the art of war, both in its instruments of destruction, and its appliances for saving life, as well as many interesting records of what

has been so wonderfully developed during the late war in respect to the quartermaster department in a sanitary point of view. Any amount of models of crude invention will find their way there; but to what extent the mechanical talent of the country will be shown by machines now celebrated in this country, and we may say peculiar to the country, remains to be seen. Philadelphia has been noted for some years for the superior class of machinist-tools. We hear that a leading firm in this branch of manufacture will send many valuable representatives of their work. It may also be noted that an important French invention, viz: the Giffard Injector, for supplying steam-boilers with water, has been, in this city, so improved by the American makers, as to go back to its place of origin almost a new instrument, simplified and rendered much more efficient. Some time during this year we will be able to present our readers with some interesting data in connection with the American improvements on this instrument. From some of the members of the Institute, who will be in Paris during the exhibition, we hope to receive many interesting facts, and should be glad to hear from those cognizant of such matters as much as possible about what is being done on this side of the water in the way of preparation. . . .

ENGINEERING ITEMS.

Railways in India.—From the report by the Government Director of the India Railway Companies, just published, we learn that the increase of lines during the year 1866, is about three hundred and eighty-seven miles, making at present the total length of tracks in that country three thousand three hundred and thirty-two miles. During this year the iron girder-bridge over the Jumna has been finished, thus completing the line from Calcutta to Delhi, a distance of one thousand and twenty miles, which may thus be now traversed in thirty-seven hours. As would be expected, only two hundred and fifty miles have been laid with double track.

A line is now under contract from Burdwau to Luckeserai at £8500 per mile, exclusive of permanent way and rolling stock, which items will probably bring up the cost to £14,000 per mile, or £2,000,000 for the whole one hundred and forty-five miles. The entire rolling stock of the Indian railways is represented by seven hundred and thirty-three locomotives, sixteen hundred cars and sixteen thousand trucks,

while four hundred and eighteen more engines are ordered, though their delivery is to be distributed over many years. The total outlay for these roads is £60,860,000, which pays an average interest of three and a half per cent.

Railway from Vera Cruz to Mexico.—An enterprise of unusual difficulty, and without a parallel in some points, is contemplated under the above title. The elevation to be reached at the summit is eight thousand four hundred feet, and this actual height must be climbed from the ocean-level in a distance of one hundred and fifty miles. The gradient is for great distances as much as one in twenty-five, and this with many and short curves. Comparing the actual elevation reached with the highest already constructed, we find that this greatly surpasses, while in no other case is the whole hill climbed, as in this case, from the very foot or ocean-level. Thus, the highest in Great Britain—the Caledonian—reaches to but one-fifth of this elevation. The Baltimore and Ohio Railroad mounts to two thousand six hundred and twenty-six feet; the summit of the Semmering incline is two thousand eight hundred and eighty-seven feet, and the intended summit of the Mount Cenis Railroad is five thousand eight hundred and fifteen feet. The engineer of this work is Mr. Samuel.

The bridge over the Niagara River at Buffalo, according to the designs of Mr. T. W. Kennard, will be constructed in spans of two hundred and fifty feet, supported on piers constructed with iron cylinders filled in with ashlar masonry, and surrounded by cribs loaded with broken stone. The total weight of each pier will be five thousand three hundred and seventeen tons. The superstructure will consist of wrought iron trussed girders, and it will carry a railway and road, side by side.

The railway bridge across the Schuylkill at Girard Avenue, for the Connecting, or Belt, Railroad is now almost finished, and presents a very imposing appearance. Its solid approaching arches, seemingly of about fifty feet span and eighty feet height, and its iron centre spans towering far above the adjacent Girard Avenue road-bridge, itself a lofty structure, are quite impressive. We lately noticed unusual activity in the operations upon the iron part of this bridge, which was explained by a glance below. The ice had formed solidly across the river, embracing, of course, the trestle-work on which the unfinished structure rested, and had this moved, as there is always risk of its doing in our uncertain climate, trestle-work and spans must have gone with it. All is, however, by this time safe.

Massive embankments are to be constructed on the Loire, the Cher and the Garonne, to protect the surrounding districts from those violent floods which have so often desolated them. The city of Tours is to be protected in some places by masses of masonry one hundred yards in breadth, as we learn from the *London Mechanics' Magazine*, page 280.

Petroleum fuel.—We read very favorable accounts of the improvement lately made by Mr. C. J. Richardson in connection with this subject, which seems chiefly to consist in the introduction of steam among the ignited fluids, by means of which it is stated the heavier oils may be burned, and these, burning, caused to yield a much larger equivalent of heat than can be obtained from the more volatile products. The convenience of a liquid fuel, in many respects, is very manifest, and if it can be brought within the requisite economic limits, its applications would be numerous and important.

A tunnel under the English channel.—We learn that surveys with reference to such a structure, have been actually undertaken under the management of Messrs. Brunel and Hawkshaw.

A tunnel through the Sierra Nevada.—A company has been formed in California for the purpose of carrying the water of Lake Tahoe to San Francisco by means of a tunnel, which will traverse part of this great range.

Experiments with Nitro-glycerine, (or, as it may be more briefly called, nitroleum,) made by M. Kopp, show that fifteen grammes (about four pounds) of this substance will detach about seventy cubic metres (= two hundred and fifty cubic yards, or four hundred tons) of hard rock.

The raising of a sunken steamship, by the application of centrifugal pumps, was lately accomplished with great success by Messrs. Gaurlay Brothers, of Dundee.

The vessel raised was the steamer *London*, which sank in the river Tay, in consequence of a collision with the screw-steamer *Harvest Home*.

The leaks in the injured vessel having been repaired as far as practicable by divers, the last and successful trial with pumps was made on the 24th of December. Five centrifugal pumps of Gwynne's pattern were used. Two of the largest, having twelve-inch suction pipes, were placed on a steamer, (the *Queen*,) and arranged so as to be driven independently from her screw-shaft. Another pump, with nine-inch suction-pipe, was placed in a lighter, and driven by a separate engine.

Two other pumps were arranged on the deck of the *London*, with a donkey-engine to work them, which was supplied with steam from the boilers of the *Queen*.

With these appliances the vessel's deck was dry in twenty minutes after starting the pumps, and she was soon after afloat and towed off.

The ventilation of millstones.—A very important case has been lately decided in the English patent courts with regard to the above subject, the verdict being against the claimant or patentee, and securing to the public, right to use the process, which seems to be of great value, enabling more than three times the quantity to be ground, which could be otherwise worked in the same time.

The process consists simply of an application of fans, to induce currents of air through the stones in company with the grain and flour, and of porous material to separate the flour from the escaping air.

Non-explosive gunpowder.—By this title is designated a preparation invented by Herr G. A. Neumeyer, of Leipzig, which will only *explode* when closely confined, but when exposed to the air simply *burns*.

The process, as described in the English patent taken out in the name of Dr. August Klein, is the same as that for ordinary powder, except, that the "glazing" is omitted, (by which the tendency to absorb moisture is said to be decreased,) and in the proportion of the ingredients, which, compared with that of English and American powder, is shown below:

	English and American.		Neumeyer's.
Saltpetre	75·00		75·00
Sulphur	10·07	Flowers of S.	6·25
Charcoal	15·00		18·75

Experiments made in Germany and France with this powder, in the Prussian needle-gun and French infantry guns, show its projectile force to surpass somewhat that of ordinary powder; while its immunity from explosion, when not inclosed, was conclusively shown in certain experiments conducted on the cricket-ground of the Sydenham Crystal Palace, where, among other things, two kegs containing together thirty-five pounds of this powder, were ignited in a small building, and each keg having a hole five inches in diameter in the top, the powder burned away without any explosion.—(See *Engineering*, December 21.)

Novelties
IN CHEMISTRY AND PHYSICS.

A new process for the economical manufacture of sulphide of ammonium on the large scale, is published by Peter Spence in a paper read before the Manchester Literary and Philosophical Society. It consists in mixing a salt of ammonia, say sulphate or chloride, with double its weight of soda waste or gas lime, blowing into the mixture a jet of steam, and condensing the escaping gas.

The condensers must, however, be watched, as the sulphide of ammonium will at first come over so strong as to condense in a solid form. The physiological effect of this gas when present in quantity is curious. Thus, a sudden escape caused a man standing near to lose consciousness, and to become perfectly rigid in a few moments. Violent rubbing of the chest, and cold water on the head, redeveloped vitality, with violent convulsions, lasting one and a half hours, but no ill-effects were experienced the next day. This poison is sudden and violent, but if not at once fatal, seems very transitory in its effect.

Disinfectants and deodorizers.—The Lords of the Admiralty have ordered that the use of Burnett's disinfecting fluid (chloride of zinc) shall be discontinued in the Royal Navy, in consequence of several fatal cases of poisoning which have occurred from its accidental mixture with food. It has, moreover, been discovered that this fluid is not a disinfectant, but only a deodorizer. Carbolic acid is to be substituted.—*Chemical News.*

Artificial tannin may be prepared by treating lignite (wood fibre) with nitric acid, according to a process developed by Mr. Wm. Skey, and mentioned in the *London Mechanics' Magazine*, page 294. The same gentleman finds that freshly burned charcoal will remove nitric acid from a dilute mixture containing both this and sulphuric acid.

Silver may be substituted for platinum in a Grove's battery, as appears from some experiments lately announced to the French Academy, provided one-quarter part of hydrochloric acid be added to the nitric. A film of insoluble chloride in this case protects the plate. The fumes of chlorine which must undoubtedly be added to those of nitrous acid, would, however, prove, we think, a serious objection to the use of this plan.

Instantaneous photographs by artificial light, we see an-

nounced by some of our contemporaries, and on looking the subject up we find that the idea, originates with a plan devised by a Mr. T. Skaife, and for which he has secured provisional protection. The apparatus and manipulation are fully described in the *British Journal of Photography*. We do not, however, perceive from the account given, how sufficient power is obtained to render an instantaneous illumination effective in producing a picture. Burned in the ordinary way, it takes many grains of magnesium, burning for some fifteen seconds, to produce the effect, and we do not understand how a "few grains" burned in a flash, can accomplish as much.

Spontaneous ignition of colored fires.—From some experiments made by Chas. Bullock, Esq., of this city, it appears that the use of flowers of sulphur in these mixtures is a fruitful cause of such action. By preparing a material without this ingredient, which may be very successfully accomplished in most cases, it will keep well for years.

Philosophical toys.—We have just received from Messrs. Queen & Co. a number of articles which may well come under the above title, and which have many points of interest in a scientific direction. They may be described as follows:

Japanese matches.—These are little allumettes of soft paper, having about the thickness of straws, and being about three inches long. They are to be ignited at one end, and burning for a few moments, accumulate a little ball of melted matter from which are emitted a series of the most beautiful flower-like sparks. The preparation of these articles is fully described in the *London Chemical News*, December 24th, 1864, and January 27th, 1865, and consists in grinding together two parts of sulphur, 1·5 parts of lamp-black and four parts of nitre, care being required to give the exact amount of comminution necessary.

Chinese straws.—These have the exact appearance of such fragments as break off from a whisp-broom, but when thrown on a vessel of warm or even cold water, expand into sprays of flowers, birds, figures and other objects.

Mr. Coleman Sellers some months since examined these curious things, and with his usual sagacity soon discovered the method of their manufacture, and produced a number of them himself. A block or bar of pith is taken and carved into a profile likeness of the object to be represented, so that a cross-section made anywhere in its length will show the same figure. (The sticks of candy containing names will illustrate what we mean.) The surface is then colored and the whole

block is compressed from the sides, in a vice, until reduced to a thin plate. This is then cut with a knife into thin slices or straws. Each of these when expanded by imbibing water shows the original profile or cross-section of the block.

There are many more of these toys among the collection above mentioned, but our limits oblige us to defer further description to our next number.

Crystallized cards.—From Mr. James T. Shinn we have received specimens of cards, covered with a beautiful silky crystallization, which is under the enamel and does not prevent successful writing or printing on the surface.

The plan was first suggested by a French article of the same kind made with acetate of lead, which was very objectionable on account of its smell and poisonous properties. The salts here used are, however, inodorous and innoxuous, and the effect produced is very beautiful. The principle on which these preparations are based have been very fully discussed in a series of papers on the crystallogenic force, published in the *Comptes Rendus* for 1864, by M. F. Kuhlmann. The experiments leading to this improvement were conducted by Mr. Robert Fairthorne, in conjunction with Mr. Shinn, and the cards are now manufactured by Mr. Collins.

Paper which turns pale ink at once black, called by its inventor, Mr. J. E. Hover, carbonized paper, has been submitted to our examination and experiment. The action claimed is undoubtedly effected, and this without any detriment to the character or durability of the paper, since the means employed is the introduction into the glazing of a neutral carbonate, which, while effecting a prompt oxidation of the ink, has none but a beneficial action on the fibre of the paper

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To Our Readers.

THE change of management and other alterations in this *Journal* have caused some delay in the issue of the January number, and in the pressure required to make up lost ground in the present issue, many articles of interest have been crowded out. It is thus that some continuations, such as that of Mr. Coleman Sellers' paper on Journal Bearings, the entire Educational Department &c., have been omitted through delay of engravings and the like. These things are not, however, lost, and will be brought out with the more completeness for the delay.

Civil and Mechanical Engineering.

THE STEAM BOILER.

By Joseph Harrison, Jr., Philadelphia.

Of all the elements that have been pressed into man's service, to increase his comforts and conveniences, water turned into steam holds a most important place. And strange as it may appear to the uninformed, it might almost be said, that the steam-engine as matured by James Watt, came from his hands nearly perfect in principle, and, like Minerva from the brain of Jupiter, fully armed and ready to do battle in the varied fields in which it has since been employed. James Watt knew all, and acted with a knowledge of all, or nearly all, the principles that are now known. The main improvements in the steam-engine of our time, consist in a better and simpler arrangement and proportions of parts, better material, better workmanship, and vastly increased size. Many of its better qualities are the result of improved means of manufacture in the use of the steam-hammer,—the planing machine, slotting machine, etc., etc., which with equally improved quality of material, has enabled the steam-engine builder to do such work, as could not have been done under a less improved system, and for which Watt might have sighed in vain.

Not so the steam-boiler. It, from the very first application of steam as a useful agent, has been the constant trouble of the engine-builder, and the engine user, the great source of anxiety, danger and expense. The first patent regularly issued in England for a steam-boiler, dates about a century back, and from that time to this, patents for new designs or improvements, numbering thousands, have been issued in England,—on the continent of Europe, and in this country. Notwithstanding the vast amount of labor and thought that has been bestowed upon the subject, the whole engineering profession still is in doubt as to which is the best steam-boiler, no single one, at this moment, proving so much better than the legion that surrounds it, as to take any very prominent place in the general estimation, and not one combining the most important principle of security against destructive explosion. We might, perhaps, except the locomotive boiler; but even this occupies

its apparently permanent place, more because it adapts itself to the machine in form, than from any inherent value possessed by it as a safe or economical steam generator. Stone, wood, cast and wrought iron, copper, steel and various alloys of other metals, have been tortured, bent and twisted, from the beginning, into almost every conceivable form to make a steam-boiler. Still the work of change goes on, patent upon patent being continually issued for attempted improvements in this much needed object. In the various phases in material and form through which the steam-boiler has passed, it is remarkable that changes have tended more towards saving weight, cost or fuel, than in the more important object of making it safe from explosion. It can hardly be controverted that the paramount aim in the use of steam should be safety, and yet, with all that has been done, no single boiler now in general use, *approaches* this essential requisite in its construction, compared with what is demanded of it. Hence the frightful loss of life—the dreadful maiming and suffering that we find recorded almost daily in our newspapers, and the immense amount of valuable property annually destroyed by steam-boiler explosions. It may be said that there is no remedy for this state of things,—that all has been done and is being done, that skill and ingenuity can devise, to stop such fearful results, but as yet without success. If we *have* arrived at the end, and found no remedy, then must we accept the situation, trusting rather to Providence, care or chance, to protect us from harm, than to any inherent controlling principle in the thing used, voting steam a good servant but a very bad master.

Before concluding this paper, I will endeavor to show that all has not been done in the general use of steam to render it as safe an agent as its wide-spread utility and necessity demand. Nay, more, it will be shown from many years of practical experience in the use of a steam-boiler of singularly original design, and of material not heretofore considered best for the purpose, that the employment of steam at any practicably useful pressure, *can* be made entirely safe from any explosion destructive to life or property.

Some give to Dr. Alban, of Plau, in Mecklenburg, the credit of first enunciating the grand idea that "*all boilers should be so constructed that their explosions may not be dangerous;*" but it is scarcely possible that Evans, Hancock, Gurney and others at a much earlier date, should not have as fully appreciated this most important principle. When the low pressure of the earlier era of the steam-engine was used, the form or material of the steam-boiler mattered little, and we find Savery

using cast iron, Newcomen wrought iron, but from the difficulty of getting good plates of the latter material, Watt even recommended that boilers should be made of *wood*, hooped in the manner of the soap boilers' kettle, with cast iron curb or furnace at the bottom. But when the first really high pressure engine was introduced by our own countryman, Oliver Evans, carrying steam as high as *one hundred pounds to the square inch*, and upwards, it then became necessary to look for material and form capable of sustaining such pressure. Oliver Evans used wrought iron plates in plain cylinders of any given length, and of small diameters, sometimes, with internal return flue, through which the heated products of combustion passed, after coursing the whole length of the lower half of the boiler. These two kinds of boiler are at this day more extensively used in the United States than any other, and may be found almost exclusively on our Western river steamers. Perhaps no other boiler now in such general use, has greater safety in its principle of construction, than this early introduction of Oliver Evans. It is true that the most disastrous explosions on record have occurred with cylinder boilers on our Western rivers, but these calamities have been the result of scanty proportions in the first place, in order to save cost and weight, or from depreciation after long use, rather than from any original defect in principle. If the grand idea insisted upon by Dr. Alban be the true one, then have our engine-builders wandered far away from it since the days of Oliver Evans. Look at the immense structures built up of wrought iron, now so largely made and used on ocean and river steamers! Is this principle of safety attained, or even aimed at, in these boilers? Are they so made that "*explosions are not dangerous?*" Witness the disaster on board the North River steamer *St. John*, in 1865. Here a boiler exploded, made on an approved and often used plan, which, according to the testimony of experts on the Coroner's jury, "*pulsated*" at every stroke of the engine. Has any one seriously considered what this "*pulsating*" means? If anything, it means a movement in certain parts of the boiler, which being kept up for a given, and almost calculable length of time, must inevitably destroy the structure of the material of which these parts are made, and which, like the *wire*, bent backwards and forwards continuously, will eventually break. It is but too true, and not very assuring to the traveling public, that all of the best ocean steamers, as well as those on our rivers, lakes and sounds, have at this moment, boilers theoretically, if not actually, as unsafe as the one that blew up in the *St. John*. It is not too much to say, that all boilers of large di-

mensions, whether of square form, dependent upon stays or braces for their strength, or cylinders of large diameter, with or without internal flues, cannot be safe. Neither is it too much to say, that no boiler is safe, whatever its form or material, that can, under any circumstances, rend and scatter large masses of material, liberating at the same time large volumes of highly charged water and steam.

Take a boiler, if you please, that depends entirely for its strength upon being properly stayed, and there are thousands of such in use, especially for marine purposes. In the nature of boiler work, it is not possible to make such a boiler safe. Let any one, with a full knowledge of how it should be done, watch the making of such a boiler. The drawings are perfect, every strain calculated to a decimal, every proportion exact. If it were possible to execute the work just as laid down, all might be well: but if such a thing is possible, we never have seen boiler work made with such accuracy. In the matter of the stays, (a most important point,) every hole should be exactly smooth and true, and made to come in true line with the one it has to meet. Every bolt should be turned and fitted to its appropriate hole. But all who are acquainted with boiler work, know that it is not even attempted to do it in this manner. Ill-shaped stays, badly made and badly fitted, or strained into ill-shaped places, often out of reach of the eye and hand of the workmen, rough holes most frequently made in the smith's shop, with as roughly made bolts. If the holes are bored, so rudely do they adjust themselves to one another, that the ever ready drift, that bane of safe and good boiler work, brings the parts together under a tension that puts to flight all decimal calculations, and but too frequently dismembers the parts themselves. Can such a boiler be safe? And again, take plate riveting. An English writer on the subject says: "It is a truism, 'that the strength of any structure is its weakest point; but who can say where the weakest point of a steam-boiler is, as ordinarily made?'" "Take a simple cylinder boiler, for instance, the sheets are run through the rolls and bent to the proper radius, and when the riveting gang get to work they close up the rivets with great rapidity, but when the holes come out of line with each other the drift pin is resorted to, and the sheets are literally stretched until the rivets can be inserted; when the drift pin is knocked out, the sheet goes back to its place, and there is already, without a pound of steam pressure, strain enough to cut the rivets off." "Repeat this performance through twenty or thirty feet, the length of an ordinary cylinder boiler, and who can say where the weakest point of the structure is? Suppose such a

boiler made of silk or any flexible material, what shape would it be in?" "It would be full of puckers, folds, seams and gathers, and represent most accurately the various trials to which that most abused of all modern engineering apparatus—the boiler—is exposed." "The case is aggravated, not benefited, when we construct a square boiler, for this shape seems, by general consent, to have been adopted for marine service." "When the angles or flanges of the sheets are not broken by the flange turners, they are cracked out by the drift pin of the riveting gang, and it ought to be made a capital offence to have such a tool (drift) on the premises of any boiler works." "New boilers burst under the most mysterious circumstances; old boilers are patched and then burst; and we are told that 'putting new cloth into old garments is the solution of the trouble.'" "On each occasion the Coroner examines a host of 'experts,' who proceed to declare that the 'iron was burnt,'—'the water low,'—'the stays insufficient,'—'the water changed into explosive gases,' etc.; but it never occurs to these worthies, that the actual strength of the boiler was, in many cases, unknown, and that it may have been at the bursting point for many days, weeks or months, until at length it gave way." "It is ridiculous to suppose that safety is secured by neat-looking rivet-heads or handsomely caulked seams." "Holes will come out of truth with the utmost care, especially in such hap-hazard work as punching is usually made." "Neither are the braces (stays) properly set, for some draw all one way, while others do not draw or hold at all, and are perfectly loose; thus a portion do all the work, and the rest are idle; they impart no strength, and are an element of weakness; for the engineer relies upon them when they are doing no good." "We are confident that a great deal of attention can profitably be given to the mere workmanship of steam-boilers; they are not tanks for boiling water, but great magazines wherein tremendous power is stored, the safe custody of which is of paramount importance to all in the vicinity."

Assuming that a boiler of large dimensions, whether cylinder or marine, *can* be made so that all the parts are joined together without strain, this state of things can only exist at the uniform temperature throughout, under which the boiler has been made. Put fires at white heat, into or under such a boiler, heating the plates in the immediate vicinity of the fire, as must occur, in a much greater degree than at the external or more remote parts of the structure. Surely then the parts that had previously lain quietly together, assume a new and constantly changing condition, and who can tell what these changes are,

their frequency, or to what extent the strength of the boiler is impaired thereby?

Let us now turn our attention to another equally, or perhaps more, important point, than those we have been considering,—the wear and tear of plate-iron boilers. A writer in the *London Mechanics' Magazine* says: "It is not too much to say, that nine out of ten explosions are directly the result of corrosion." "Setting aside the value of human life and limb, we find that the mere pecuniary interests involved in either the gradual or sudden destruction of a boiler are very considerable." "Repairs are, at all times, expensive, and the time lost in making them is often a serious source of pecuniary loss, worry and trouble." "Hence the replacement of a plate, or the alteration in a defective flue, is often staved off from day to day until irreparable mischief is done." "Reflecting upon these things, it seems strange that boilers are made, fired and worked with a negligence, which apparently regards iron plates as indestructible, and the results of an explosion trifling to a degree." "We cannot set such a system,—or rather such a want of system,—down wholly to stupidity or neglect." "We know that boilers in the best hands, and under the most careful management, often become worthless with a startling rapidity, which no amount of theoretical reasoning can account for, nor practical skill arrest or delay." "The utter uncertainty in which the engineer is doomed to live, as to what does or does not promote durability, leads naturally to recklessness, neither the result of want of thought or indolence." "Corrosion is too often regarded in the light of a fate—a destroyer, merciless and indiscriminate, before which as a *fetish*, the manufacturer and ship-owner bow down and submit."

Mr. Colburn, in a paper read before the British Association, in 1864, says: "As a boiler malady, corrosion corresponds in its comparative frequency and fatality to the great destroyer of human life, consumption. It is the one great disease." "A trickling of condensed steam down the outside of a boiler will inevitably produce corrosion, and to this, was directly traced a large number of the forty-seven boiler explosions which occurred in the United Kingdom in 1863, and which caused the loss of seventy-six lives, with injuries more or less serious, to eighty persons."

In the report of the Manchester and Midland Boiler Association, for 1863, we find the following: "Furrowing along a seam of rivets, or rather under the line of an overlap, is found to be the usual malady, but the iron is eaten away almost everywhere; not uniformly over the

whole surface, but in numberless holes." "So far as furrowing is concerned, there can be no doubt that wrought iron is the *worst* material that can be employed for a steam-boiler."

Thus much on the subject of corrosion. Says another article in the *London Mechanics' Magazine:* "Until a comparatively recent date the belief obtained with most engineers, that a riveted joint, if the work were properly done, was superior to the plate itself."

Mr. Wm. Fairbairn, in a series of carefully conducted experiments, upset this fallacy by proving that, "the strength of the plate being taken as one hundred, that of a double riveted joint will be seventy, and a single riveted joint fifty-six;" and this with first rate workmanship. "Fifty-six per cent. of the whole strength of boiler plates, is certainly not much to realize with the best workmanship, but as many boilers are put together, this per centage must be regarded as too high." "There are difficulties involved in the nature of the process, which the best mechanic can only combat,—seldom or never overcome." "However accurately two plates may correspond before being punched, that process inevitably distorts them, and occasions a bad fit when subsequently put together." "The hammering and bending at the edges is invariably injurious to cold plates." "Again, the best workmen, with the best machinery, find it out of the question to make all the holes in a long seam correspond." "The constant use of the drift is certain to follow, and when plates are of inferior quality or very thin, cracks are frequently established from one hole to the other." "The judicious use of the caulking chisel easily conceals the defect, which is none the less serious because it is invisible." "The best rivets too seldom completely fill the holes they occupy." "They are never truly at right angles to the plates, and are often exposed to enormous strain in drawing plates together when they are badly fitted." "We have seen, from this cause, the heads fly off half a score of '*Best, Best,*' rivets at once, in rolling a new boiler from one side of the shed to the other."

Blistering of plates is another trouble in the use of plate iron. Says, —*Engineering Facts and Figures*, for 1863, page 21, "The fact of plates by good makers being liable to blister unawares, and which previous examination fails to detect, shows the importance of not hazarding an expression upon their soundness. Thus the strength of no unassisted plate, exposed to the action of the fire, should be relied on, and consequently it becomes most desirable that furnaces should be in every instance stayed either with flanged seams, or with hoops of angle iron, T-iron or other advantageous form." Thus, at every turn, the

boiler-maker, in using wrought iron, either in plates, rivets or stays, meets with difficulties which can only be partially, never perfectly, overcome. These difficulties occur most frequently at the very points in the structure where danger from defective work or material is most imminent, and where it is least easy to avoid it.

The maintenance of a well made steam-engine is of slight import, nor does the engine proper give the user any great anxiety or trouble as a source of danger to life or property. So true is this, that engines are doing good service now in England, that were made by Watt and his contemporaries; the sun and planet-wheel even yet making their regular revolutions. Where are the boilers that started with these engines? Gone, gone, and many succeeding the first, gone also.

The elements that destroy a steam-boiler commence their work from the moment of its completion, and from the hour it is first filled with water and fired; whether much used or not, the slow, steady, insiduous process goes on, and it is fortunate if its life reaches a decade, ere it is thrown out as worthless, scarce selling in this country for one cent per pound, even after its full original cost has been expended in almost continuous repairs from the beginning. From *Engineering Facts and Figures*, for 1865, we quote the following: "The saying of that distinguished authority in matters mechanical,—Wm. Fairbairn,—'that danger in the use of high pressure does not consist in the intensity of the pressure to which the steam is to be raised, but in the character and construction of the vessel which contains the dangerous element,' may be set down as a truism, containing a great deal of suggestive truth, but which is often overlooked, if not entirely ignored." "Else how is the public sense of what ought to be, but unfortunately is not, every now and then shocked by a recurrence of those accidents which result in such extensive loss of life and property." "It is the saying of one who has said many good things in his day, that 'self-interest is always intelligent.'" "In the matter of the use of boilers notoriously defective in form, material and construction, self-interest is *not* always intelligent; for however easily employers may take the loss of life from accidents in the use of steam-boilers, one would think that self-interest would prompt them to avoid, by all means in their power, the loss of property."

What are the conclusions that are forced upon us by all that has been adduced? Plainly that wrought iron is entirely unfit for steam-boilers,—that it is unreliable and unsafe to use it for such purposes, and that neither in principle nor workmanship in the use of this ma-

terial, have we advanced one step, in a century, towards making the steam-boiler, as now generally used, safe from destructive explosion. On the contrary, just in proportion as we have increased the working pressure, so have we run into greater danger; and at this moment boiler explosions are more frequent and more fatal in their consequences than ever. It is a sad condition of things that this much needed and much used force should be so little within our control. Must these mines of destruction, placed in our cities and towns, under our feet as we tread the side-walk, and all around us, threatening at every moment our very households with destruction, still hold their pent-up wrath by so frail a thread? Is there no way to safely clip the hair, and thus let the sword now hanging over our heads, fall harmless at our feet, there to lie harmless forever? I think there is a way to do this. If this can be shown, then let no one say hereafter that steam-boiler explosions cannot be prevented. Says Mr. Wm. Fairbairn, whom we again quote: "Instead of working two hundred pounds pressure to the square inch, I think we shall reach five hundred pounds." In *Engineering Facts and Figures*, for 1863, in treating of the great need of improvement in marine boilers, we find the following: "The answer is obvious,—no further economy can be obtained in steam-power without the use of *high pressure* and expansion." Ocean steamers, twenty-five years ago, used three or four pounds pressure to the square inch. Now the Cunard steamers use twelve or fifteen. Our North River and Sound steamers, the pioneers in using much higher pressure condensing engines, carry thirty or forty, and even fifty pounds to the square inch. Common consent, if not necessity, demands higher pressure, and it behooves the engineering profession to look to it, that we do not continue the present imperfect and most dangerous system, if there is any way to avoid it. It is a sad story of disaster in the past. It is meet and necessary, that the long-time reproach should be removed. Enough, we think, has been said to convince the most prejudiced that a good, safe and durable steam-boiler *cannot be made of wrought iron.* Assuming this to be proved, in what direction must we then look to find a better and more reliable material for the purpose,—one not possessing the many inherent and insuperable defects of wrought iron, one that can be readily made into such forms as will most conduce to the safety, durability and economy of a steam-boiler.

Turn we now to cast iron,—early used, but heretofore and even now, generally supposed inferior material for steam-boilers. On the subject of cast iron, a writer in the *London Mechanics' Magazine*, for May 2d,

1864, uses the following language: "There is a French proverb which says, that we always return to our first love, and it is by no means unlikely that this will be verified in boiler engineering. At one period it is beyond question that cast iron boilers were habitually used for very high pressures, and they were used because the material possessed constructive advantages which were not then believed to reside in wrought iron, and if these advantages reside in it still, under a principle of construction modified to meet existing demands, there is no good reason why it should not be habitually employed. Cast iron is far better adapted to meet the ordeal of fire and water to which a boiler is exposed than the best wrought iron plates ever manufactured. As to strength, we all know, or ought to know, that that is a matter of proportion quite as much as a matter of material. There is nothing like practical illustration to bring such truths home to the mind. Let us suppose, then, the case of two boilers, one made of plates half an inch thick, and the other one quarter of an inch thick. If each of these boilers is, say, six feet in diameter, the first one will possess, as nearly as may be, double the strength of the other. To render both of equal strength it is only necessary to reduce the diameter of the thinnest one to half the diameter of the thickest." "In the same way, it is certain that a cast iron tube, of a given diameter, may be made quite as strong as one of wrought iron of the same thickness, provided the diameters are proportioned the one to the other, in the ratio of their tensile strength. That the arguments adduced against the use of cast iron, are many and powerful, we do not pretend to deny; but that they are invariably applicable, or that it is, in other words, impossible to devise a boiler that shall elude these objections, is false." "We daily see cast iron used to carry enormous pressures with the utmost confidence. Its tensile strength may always be brought, in one sense, up to wrought iron by using enough of it. It has thus beaten wrought iron, in the form of guns, many times. There are two ways of increasing the strength of any vessel; the one in increasing the thickness, the other in reducing the diameter of the globe or cylinder to be tested. It is obvious that cast iron can only be used in small tubes or chambers, inasmuch as larger vessels must necessarily be of such a thickness that heat would pass through it very slowly indeed. But this fact in no way militates against the safety, economy or efficiency of a generator. Perhaps the present system of employing wrought iron boilers of colossal dimensions in our every-day practice, has been productive

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of more injury to life and property, than can be laid at the door of the engineer on any other ground."

In a leading article in the *Engineer*, for 1864, it is said: "It has been so long the custom to consider cast iron as a brittle material, hardly to be trusted under pressure, that it requires some amount of reflection to perceive wherein it possesses manifest advantages over wrought iron. The resisting strength of a properly made cast iron boiler is calculable, and a good *a priori* case, could have been made out in its favor, long ago." What if the very brittleness of cast iron, when used in a steam-boiler, should prove an element of safety?

In an article in the *American Artisan*, for November 22d, 1865, in answer to an assertion made in that journal, referring to the Harrison boiler, that, "cast iron was not to be recommended for steam-boilers," because it "was liable to be strained from inequality of temperature," I have said, "Many years of experience in the use of this boiler has taught me that as a material for steam-boilers, cast iron is far preferable to wrought iron, and for a reason that can be very easily understood. Cast iron is *not* liable to be strained 'by inequality of temperature;' it is liable to *break* from such cause, and will give out at once if badly proportioned or improperly used. Wrought iron in steam-boilers *is* liable to be strained by 'inequality of temperature,' and not fracturing at once, goes on straining until its structure is destroyed, and the parts thus strained inevitably give way, death and destruction too often following. Put cast iron in such form as will prevent harm in case of rupture, and it becomes the *very best* material for steam-boilers, and one of its best qualities is in giving out when badly treated, a warning not to treat it so again. Not so wrought iron; its very tenacity begetting a false security which might lead to disaster at any moment." It certainly appears strange at a first glance, that such a seeming bad quality as brittleness in any material, should make it more reliable than a more tenacious one, for purposes needing strength. It would appear more strange, if this should prove true, in a material for steam-boilers.

(To be continued.)

(Continued from page 14.)

THE NEW YORK "CENTRAL PARK."

By WILLIAM H. GRANT, Superintending Engineer.

CHAPTER I.

ON ROADS, ROAD-MAKING AND ROAD-MAKERS IN GENERAL.

THE necessity, from remote times, for road-making; but little rest for the hand of man in the business. Long practice has not made the art perfect. Various plans tested in Park construction. Difference in cost not great between good and poor roads. A knowledge of road-making does not "come by nature." Inconsistencies of the public. Public views as to the constructive arts. Our early engineers. An unfortunate inheritance of the profession. The progress since made by the profession, and what it has done. Prejudice as to engineers' estimates and economy. A word to young engineers. Roman roads. English roads in the last century, and the improvements that followed. A new era. English road-makers. Origin of McAdam roads, and of Telford roads. Indestructible roads, as the Roman, the Russ and iron pavements, not practicable. Foundation work should be permanent. Trap-block pavement. Common roads in the country.

The art of road-making is quite a venerable one from its antiquity. It would scarcely be a figure of speech to say it was "as old as the hills"; for, if we may believe the geologists, hills, mountains and valleys have been formed within quite a recent period—are, in fact, still in process of formation. However this may be, the transformation of the surface of the earth, from its primeval condition to its present rugged character, doubtless lies at the bottom of the business, and has been the chief provocation to the introduction and practice of the "art and mystery" of road-making. It is quite certain that, from an early period down to the present day, whether from the "upheavals," "depressions" and "denudations" of geologists, or other moving causes, there has been a constant necessity in the intercourse of mankind for making rough ways smooth, and crooked ways straight, and that there has been but little rest for the hand of man, through many successive generations, from road-making labors. It would be natural to suppose, that from long practice the art would have made such advances ere this as to have precluded the saying of much that is new or instructive in regard to it.

The multiplication of examples, experience, traditional knowledge,

treatises and theories has really been such as to make it appear a work of supererogation to attempt to add anything more upon the subject. Still, the subject has not been exhausted, and this arises from the fact that varying necessities and circumstances are constantly occurring, requiring new adaptations and new applications in the channels of human intercommunication, and the art that applies to them must therefore be progressive, and subject to improvement like most kindred arts of human origin.

A reference to past experience, ancient as well as modern, is useful to the road-maker of the present day, but it will not meet fully the requirements that will be made upon him. The supposition may be plausible, that whatever is odd and long-tried is the safest guide to follow; but something more than precedent and routine must be looked to, to meet the present and future demands of the art. Whoever sets about the work and attempts to carry it out practically, on any considerable scale, will be met by these considerations; he will find that, with all the light of the past, except that which is reflected from sound general principles, he must rely very much upon his own resources, cultivated judgment and skill, for success.

The conditions of the problem are too variable to be governed by fixed and uniform rules. Expediency, feasibility, special adaptation, questions of cost and materials, influence of climate and various other matters, will in turn, singly and in combination, arise to be passed upon. The road-maker who is not prepared to deal with them judiciously, without recourse to the rule and plummet of precedent, will often be sorely perplexed. If he is inclined to rashness, he will probably escape from the dilemma, for the time, by committing a blunder. If he takes the more prudent course he will retrace his steps from unsafe ground until he acquires the means of obtaining a safe footing.

Modern treatises upon road-making contain much that is valuable and indispensable; but, at the same time, they reveal a great contrariety of opinions, practice and results, that has been found, after a good deal of attention given to the subject, to adapt them rather to the closet of the student than to the field of the practitioner.

The writer does not, of course, expect here to supply a desideratum in these matters. Allusion is made to the facts as they have been found to exist, in order to direct attention to necessary principles and resources; and beyond this he has not the presumption to attempt to do more than give a description of his own practice (which has occurred under circumstances more than ordinarily favorable) to pass for whatever it may be worth.

The scale upon which the Park roads have been constructed, and their general object, have been favorable for testing, in a thorough manner, some of the principal modes of road-making in vogue, and for perfecting, beyond ordinary practice in this country, many of the details of the work. It was proper that these roads should be of a superior description in all respects, and that no efforts should be spared to adapt them, in the most complete manner, to the end designed. It was not only essential that this should be done as to mere external appearances and accessories, but that they should be fitted for durability, safety and easy practical maintenance. These considerations, combined with the endeavor to pursue the soundest economy, and to avoid hasty and ill-considered expedients, have governed their plan and execution. No extravagant or lavish notions have been indulged in, nor have means been misapplied in experimenting.

The expenditure incurred, though large, could not have been wisely less, so far as the actual service and permanency of the work is concerned. If it had been less, it would not have been conducive to economy in the end.

Much of the cost of the roads was, of course, for the rough grading over expensive ground, peculiar to the locality, and a good deal was owing to the unusual widths as compared with other roads, but for the work pertaining to the service and wear on the superstructure, no more cost has been incurred, proportionably to the width, than is frequently expended on roads of an inferior character; for, although it has been found by experience that it is not as easy a matter to make a good road as is popularly supposed, yet it is believed that the difference in cost between a good road and a poor one, made as the latter frequently are made, need be but very little; cases could even be cited in which it has become painfully evident that more money and hard work had been expended to accomplish a *failure* than would have been needed to ensure a *perfect success*. One reason for this has been found to be the desire on the part of the public to make cheap roads, or what are fallaciously supposed to be cheap roads, by the employment of cheap materials and cheap labor, and another is the prevalence of the idea that every man may be his own road-maker, and that all necessary knowledge of the art "comes in someway by nature."

Incompetent and unfaithful agents are employed, and the result is too frequently found to be, that the road falls into the large class of very "common" roads of the country, is a vexation and an annoyance, and, in the end, quite the reverse of a cheap one.

It is doubtless among the besetting sins of professional men to magnify their office, and attach undue importance to the knowledge and experience they have gained by long study and practice, and to proportionably underrate or distrust the abilities of others who have not in like manner qualified themselves for the duties they assume; but if this is the case, it must be conceded that there is some extenuation for it, in the striking examples of ill-success by inexperienced persons that are so frequently brought to their attention.

There is a singular inconsistency exhibited by many persons in the selection and employment of agents for various professional duties. A man, for instance, who needs the services of a physician, or a lawyer, seeks among those professions on whose science, skill and general reputation are well attested by previous success, or whose initiatory training has been such as to give a well-grounded assurance that he will ably discharge the duties of his office; but when it comes to the selection of agents for the performance of many other duties that have required an equal degree of study and practice to become proficient in them, the same individual will be found to depart from the rule, to relax his judgment and take up with the services of those whom he knows, or easily might know, have been imperfectly or not at all fitted for the duties they undertake to perform.

It is a matter of surprise that this want of discrimination is so often manifested by men of a high order of business qualifications, who, when they step aside from their routine occupations, in which they have been uniformly successful, and undertake other enterprises, seem to act upon a maxim at variance with all their previous habits.

Examples of this kind could be cited, but they have so frequently occurred that most observant persons will recall them in one form or another. Many remember them, as the writer has reason to know, to their cost, and have grown wiser by dearly-bought experience.

It might be explained, perhaps, that in regard to the constructive arts, and especially those that belong to civil engineering, popular opinion does not as yet in this country, attach the same importance to preparatory studies and qualifications as in the case of the older professions. It is scarcely fifty years ago, dating about at the commencement of the Erie Canal, that civil engineering took the position of a distinct profession among us. We had, at that time, no native engineers who were educated as such, and as a preparatory step in un-

dertaking the public canals, one or more foreign engineers were employed.*

The profession grew up with the occasion, and under great disadvantages, active and energetic men, whose theoretical and practical knowledge of the business was limited to the requirements for land-surveying, constituted the material first drawn upon.

They produced certainly very creditable results, creditable to themselves and of great and lasting advantage to the country, but perhaps not fortunately for their successors. If men could accomplish, extemporaneously, and without previous training, what they did, what need of higher culture and a long course of study and practice? Have not the public continued to reason upon such grounds until they have lost sight of subsequent progress and subsequent results, and in their admiration of the works of Geddes, Wright and others of that day, have forgotten the more perfect successes and surpassing achievements of Latrobe, McAlpine, Whistler and many others of a more recent period. There seems to be an obliviousness to the fact, that although the profession entered the lists at a late day, and had many obstacles in the way, it has made rapid advances, and, with the speed of the ocean steamer, the locomotive and the electric telegraph, has long since overtaken the more favored professions, and is prepared to keep even pace with them towards the common goal.

It would be difficult to point to any page of history that exhibits greater changes and improvements, in the same space of time, than have been wrought in this country, within the memory of the present generation, through the instrumentality of the engineering profession, rising in proficiency with the emergencies of the occasion, and elevating its standard quite up to the height attained in the older European countries.

But there is another phase in this matter of our early engineer and engineering that is not to be overlooked.

Notwithstanding the praiseworthy deeds of the pioneers of the profession, they were, alas! mortal, and they committed some errors, and although their virtues have been tenaciously remembered and acknowledged, they have not been sufficient to cover these errors up. The evil that was done by them has not been "buried with their bones."

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* It is gratifying to be able to say that we have repaid this obligation in sending abroad many American engineers, in compliance with invitations from foreign governments, and they have done the profession much credit by their works and inventions.

They were charged with being extravagant in the expenditure of the public money, and with forming insane and visionary plans, with being untrue prophets in predicting certain financial results in connection with the fulfillment of their plans,—in short, of making delusive estimates, and besides being charged with what they possibly did do, were charged with many things that they did not do. And these things have been looked upon by many honest-minded persons, since that time, as a sort of legacy that they have transmitted in perpetuity to their successors.

It has thus become a strong conviction with many, that to undertake a piece of work requiring the employment of an engineer, is to embark in a career of extravagance and to incur an unknown outlay. An engineer's estimate is to them almost synonymous with an ascending series of expenditures ending only with exhaustion, and his plans are regarded as ingenious refinements upon the old-fashioned ways of doing things that are inconceivable or useless. The impression cannot be eradicated with such persons that an engineer cannot study or practice economy, whatever else he may do; his work may turn out to be perfect and durable, or it may not, but in any event it cannot be a success as to cost,—in other words, cannot be cheap.

This is a part of the unfortunate inheritance of the profession. It may be that modern practice, or rather, malpractice, also occasionally gives rise to some doubts and distrust, as in other professions,—no more, no less; but it is believed that the intelligent portion of the public are becoming more discriminating than to adopt exceptions, either old or new, in place of a well-established rule; for if there is any rule or basis that is fundamental, and specially attaches to the profession of the engineer, it is that it is the art of attaining with certainty, the greatest ends with the least expenditure of means. This applies not only to the mechanical means and the judicious selection and use of materials, but to manual labor in all its forms in construction, and to the immediate, as well as remote, moneyed economy of the work.

The engineer knows this, feels it and practises it at every step; it is a part of his education, and becomes a part of his nature; he never rushes upon a work without first carefully examining it, measuring it, weighing it, and sounding it and bringing out its contingencies; he "counts the cost," lays securely his foundation, and then, if he is a true engineer as he professes to be, and not a superficial pretender, he rarely fails in his superstructure.

His peculiarity of looking into things deeper than inexperienced

and unprofessional persons, is frequently the cause of creating doubts and hesitation in the minds of such persons. His business is to look on the worst side in any case submitted to him, and to develop hidden and unlooked-for difficulties, to point them out, represent them truly and prepare the means to meet them. This is a duty not always the most pleasant; but nevertheless a duty that he cannot shrink from. It is not agreeable to be always looking for defects, and investigating chances of failure and probabilities of ill-success, especially when they are not wanted to be seen, and he can only find his compensation for it, in the assured result that in the end obtains. He is not content to place himself in the position of a trader who speculates on a small capital, and must have quick returns or become bankrupt; but if properly imbued with the true aims of his profession, looks to the more slow and substantial reward that grows out of ultimate, well demonstrated and acknowledged success. If this comes in the end, well and good,—if not, he has at least the satisfaction of knowing that it is deserved, and that he has not yielded to a culpable weakness and glossed over his work for a transient object, and at the expense of future mortification.

But this is a prolific theme that is leading to too great expansion in this place, and we must take leave of it for matters more immediately pertinent, venturing only to add a word further, by way of advice, to the younger members of the profession.

Do not be alarmed at any apparent want of appreciation, nor overanxious for immediate success or future fame. Your anxiety should be rather for thorough and substantial qualifications. If you have no cause to distrust yourself, the rest will come in due time. Cultivate a love and an enthusiasm for your profession, for if you do not enter into the spirit of it "with might and main," no success will follow; if you do not honor it, it will not honor you. If you fail to demonstrate its qualities and its power, its practical adaptation to small as well as great things, by sound and sensible practice, the public will not confide in you. Confidence is a plant of slow growth, and must be waited for patiently. Be deserving of it and you will not fail to attain it. Do not suppose that success in great enterprises alone is necessary for establishing a reputation. The watch is not to be despised because it is not as large as the town clock. A canal, a railroad or an aqueduct is a work of some magnitude, but it is made up of parts and details, each part being, as it were, a speciality in itself, and the multiplication of these adds only to the quality, not the quantity, of the

responsibility, skill or scientific attainments demanded. It is necessary to be prepared at all points. The profession is expanding with the greatly increasing demand for its application in this country, and it must be kept up to the emergency.

If it fails in its legitimate duties they will fall into other hands and bring discredit upon it, as perhaps has heretofore been the case. Demonstrate its claims to all the rounds of vocations and duties belonging to it, not by empty pretension and a smattering merely of superficial qualifications, but by the solid acquisition of fundamental principles, and by their exemplification in practice. Do this, "act well your part," and the public will not fail in the end to perceive it and appreciate it.

From the London Engineering, No. 1, Vol. II.

PINS AND EYES.

A PIN, passing through eyes formed on those parts of a machine or structure which are to be joined together, is a form of connection of most frequent occurrence, both in civil and mechanical engineering. For instance, the links of the chains of suspension-bridges are so connected, and so are the diagonals and flanges of Warren girders, whilst in machinery it forms the usual form of connection between the parts of all link-work. In all these cases, but more particularly in bridge-work, it is important that the size of the pins and eyes should be so proportioned to the strain upon them, that they be of equal strength with the parts which they connect. In machinery, where the parts are subjected to motion, sufficient bearing surface has to be provided to prevent heating, and it is generally this consideration which governs the size of the parts, those proportions which give the requisite bearing surface being generally amply sufficient as far as mere strength goes.

In those cases, also, where there is little or no motion between the parts to be joined, the question of bearing surface has more to do with the proportioning of the sizes of the pins and eyes than is commonly supposed. In such connections, the parts are almost always arranged so that the pins are subjected to "double shear," or, in other words, they must, before they fail, be broken through in two places. Under these circumstances, the area sheared through is, of course, equal to twice the sectional area of the pin, and in the case of wrought iron pins and links subjected to tensile strain, it would at first appear therefore that the sectional area of the former should be equal to half that of the latter, the resistances of wrought iron to shearing and tension being about equal. For instance, if we had two links, each with a sectional area of twelve square inches at its smallest part, and the end of one of them

was made with a double eye embracing the end of the other, then, if the resistance to shearing only had to be considered, the connecting-pin might have an area of six square inches. Whether this area would or would not be sufficient, however, would depend to a great extent upon the form of the eyes at the ends of the links. In the first place, the jaws of the double eye must be prevented from opening, and so throwing a bending instead of a shearing strain upon the pin; and, in the second place, the thickness of the eyes must be such that they have sufficient bearing upon the pin, and so do not fail from distortion. The opening of the double eye is generally prevented by means of a head on one end, and a nut, or collar secured by a pin, on the other end of the pin; but the second requirement, that of bearing surface, is very frequently neglected. In cases where, as in the links of a suspension-bridge chain, the thickness of the links is very small in comparison with their width, the bearing surface which the pins would have, if made with the proportions above mentioned, would be quite insufficient, and the consequence would be that the holes would be distorted, and the eyes torn.

When the late firm of Fox, Henderson & Co. were constructing the chains of Mr. Vignoles' suspension-bridge, over the Dnieper, at Kieff, a number of interesting experiments were tried to determine the proper proportions for the eyes of the links and the connecting-pins, and the results obtained were given in a paper afterwards read by Sir Charles Fox before the Royal Society. As the chains for this bridge weighed over sixteen hundred tons, and had to be carried from Odessa to Kieff, over three hundred miles of very bad roads, it was of great importance that all useless weight should be avoided, and consequently that no superfluous metal should be employed in their construction. For convenience of transit, the links were made twelve feet long from centre to centre of pinholes, and ten and a quarter inches by one inch throughout the part between the eyes. The eyes or heads were also one inch thick by sixteen and a half inches in diameter, and were at first pierced with holes four and a half inches in diameter for the reception of the pins, which latter had thus an area of 15·9 square inches, or rather more than half as great again as the smallest sectional area of the links. Notwithstanding this excess in the sectional area of the pins, however, they were, upon experiment, found to be quite unable to develop the full strength of the chains. The links were made from iron manufactured by Messrs. Thorneycroft & Co., from a mixture of Indian and other pig iron, and had a tensile strength of about twenty-seven tons per square inch, and each link ought, therefore, to have borne, if the pins and eyes had been properly proportioned, a strain of at least two hundred and seventy tons. Upon the test being applied to one of the links, however, it was found that it failed under a strain of one hundred and eighty tons, the head or eye tearing across at its widest part, where the sectional area was twelve square inches.

This result led to the supposition that the eyes were too small, and some experimental links were accordingly made with eyes eighteen and a half inches in diameter. These, however, were found to fail in a simi-

lar manner, the pinholes in both this and the former instance being drawn into a pear-shaped form, and the metal being bulged on that side which had received the strain. Under these circumstances it was determined to increase the size of the pins, thus giving greater bearing surface, and diminishing the intensity of the strain upon the eyes. One of the links, with a sixteen and a half inch head, was accordingly taken, and the pinholes enlarged to six inches in diameter, so that each pin had a semi-cylindrical bearing surface of 9·4 square inches instead of seven square inches, as in the former experiment; and the result of this alteration was, that the breaking strain was augmented from one hundred and eighty tons to two hundred and forty tons, notwithstanding that the head had less metal in it than before. Further experiments, subsequently made, indicated that the diameter of the pins might have been still more increased with advantage, the best proportions appearing to be those which gave each pin an area of semi-cylindrical bearing surface about equal to the least sectional area of the links. Sir Charles Fox considers that it is best to make the bearing surface slightly in excess of the proportion just mentioned, and he thus gets, for the pins of suspension-chains, the simple rule that the diameter should equal two-thirds the width of the body of the links.

As the sectional areas of the pins increase as the squares of their diameters, whereas the bearing surfaces increase only as the diameters directly, it follows that, whilst, in the case of small sizes, a pin of the requisite sectional area may give an excess of bearing surface, so, on the other hand, a large pin having the requisite bearing surface will have an access of sectional area. In cases where the pins are exposed to "single shear," the change from the one condition to the other will take place, with links one inch thick, at that size of pin, which has a semi-circumference in inches equal to its sectional area in square inches, or at a diameter of two inches; with thicker links this diameter will be less, and with thinner, greater. In pins of large size, when, in order to obtain the requisite bearing surface, the diameter is made much larger than would be necessary to give the proper sectional area, the dead weight may be diminished by making them hollow, care being of course taken that the thickness of such tubular pins is sufficiently great to prevent any distortion taking place when strain is applied to them.

In determining the proportions of the eyes through which the pins are passed, it must be remembered that the strain upon the metal composing them is not uniformly distributed, the stress being more severe upon the inner parts than upon the outer. To compensate for this, Professor Rankine advises that the sum of the sectional areas of the two sides of an eye should be made one-half greater than would be required if the strain was uniform. The experiments on the links for the Dnieper Bridge, above mentioned, show, however, that a less proportion than this is sufficient. The links tested had, when fitted with the six-inch pins, but five and a quarter inches of metal on each side of the pinhole, whilst the body of the link was ten and a quarter inches broad; and, under these circumstances, the breaking strain was two hundred and

forty tons against about two hundred and seventy tons, which, according to the trials of the iron, would have been required to break the link through the body. From these results, Sir Charles Fox estimates that the sum of the widths of the two sides of the eyes should be about ten per cent. greater than the width of the body of the links, this rule, of course, referring to those cases in which the link and eye are of uniform thickness throughout.

When circumstances will allow of its being done, the best way to obtain the requisite bearing surface for the pins connecting links of small thickness in proportion to their section, is to increase the thickness of the eyes beyond that of the links themselves. This allows the metal around the eye to be made narrower, and it thus consequently diminishes the inequality of the strain throughout its section. Where the links to be connected are of square section, or are of considerable thickness in proportion to their sectional area, this thickening of the eyes becomes unnecessary, as sufficient bearing surface is given without it. A rule, for the size of eyes, which has been much used, and which gives generally very good results, is to make the outside diameter of the eye equal to twice the diameter of the pin passed through it, and then to increase the thickness until the requisite sectional area is obtained.

From the London Mechanics' Magazine, November, 1866.

OVERHEATED STEAM-BOILERS.

A PARAGRAPH has just been going the round of the papers, to the effect that, recently, when the fireman at the Agnes Main Colliery, Barnsley, went to attend to his fires, to get the steam up, he observed that the float belonging to one of the boilers was down; and, on making an inspection, he found that the sluice-valve had been opened and the whole of the water run off. Although this was a villanous act, if wilfully done, yet we cannot help thinking that an unnecessary degree of sensationalism has been imparted to the circumstance by the various headings given to the paragraph in question, and by the further statement that, as the plates of the boiler were red-hot, had the fireman turned the water on before he made the discovery, there must have been an explosion and, no doubt, loss of life, as several persons were in the immediate neighborhood of the boiler. Granted, that the plates of the boiler were red-hot; but we certainly think there would have been no explosion, much less loss of life, had the fireman turned on his feed-water. This may appear a somewhat startling opinion to advance, and yet it is one which can be supported controversially, and, what is more, is recorded to have been established practically. Let us see, then, how stands this theory of steam-boiler explosions, which generally goes under the denomination of overheating. A great number of boiler explosions

are attributed to overheating; in fact, some theorists go so far as to assume this as the general cause of such catastrophes. Now, this theory, taken in a broad sense, is a false one, although it is possible that a boiler may be exploded by the formation of a great quantity of steam from water thrown upon red-hot plates. But a consideration of some of the phenomena of heat, places this possibility at the very farthest limit, and the occurrence of an explosion from such a cause only just within its bounds. We quench the heat of a railway tyre in a cistern, and why may we not as safely fill a red-hot boiler with cold water? It is surprising to see how small a quantity of steam is disengaged when a large body of wrought iron is plunged into twice or thrice its weight of cold water. Now, if we reverse the operation and dispose the same weight of metal in the form of a boiler, heat it to the same degree, and throw the same quantity of cold water into it, is it not reasonable to expect that exactly the same amount of steam will be produced? If so, where would be the harm done to the boiler beyond the damage inflicted upon the iron by burning?

If we look into the matter a little more closely, we shall find that the metallic plates of a steam-boiler are not capable of containing sufficient heat to change a very large quantity of water into steam. The total quantity of heat which would raise the temperature of one hundred weight of iron through one degree, would, according to the best authorities, impart the same additional temperature to twelve and a half pounds only of water. And this makes it clear that overheating is not the sole cause of an explosion, although it may lead to a rupture by weakening the plates. So much for the theory, which certainly is opposed to the doctrine propagated in the paragraph to which we have alluded. Much more so is practice in the matter, which leads us to believe that an empty boiler, however much it may be overheated, may be filled with water with perfect impunity. Indeed, it is on record that this has been done; and this was the experiment: An empty boiler, twenty-five feet long and six feet diameter, and with the safety-valve loaded to sixty pounds per square inch, was made red-hot. Whilst in this condition, the feed was suddenly let on and the boiler filled up. The experimenters anticipated a mighty explosion, for which they were fully prepared, but no such event occurred, the result being simply a sudden contraction of the overheated iron, which allowed the free escape of the water at every seam and rivet as high as the fire-mark extended. Although we were not witnesses of the occurrence, yet, arguing upon the hypothesis regarding the action of heat already referred to, we cannot hesitate to accept the fact; the more so in that we have heard of other experiments of a similar character having been made, and which were attended with similar results. The conclusion, therefore, is, that although at the Agnes Main Colliery a diabolical act has doubtless been committed, and one for which the offender should be made to suffer severely, yet no greater damage than has been done could have accrued, had the fireman turned the feed on. The result would most probably have been a rapid cooling and contraction of the plates, and, when the water reached a sufficient

height, the extinction of the fire. This may appear an unsatisfactory conclusion to some of our contemporaries, who would have the fireman and his co-workers raise a hymn of praise for deliverance from an awful catastrophe. It is, however, the only legitimate conclusion to which we can arrive upon a consideration of the known laws of cause and effect. Moreover, it is the teaching of science, the laws of which are fixed and immutable, and its facts the stubbornest of all stubborn things.

Whilst on the subject of steam-boiler explosions, we may as well pursue the matter a little further, with regard to the cause of their violence. Many theories as to the cause of the violence exhibited have from time to time been called into existence by the characteristics attending various steam-boiler explosions. Some of these find support in circumstances which are fatal to others, and *vice versa*, while most of them are open to the entire objection from their inconsistency with certain fixed laws of cause and effect. We do not, however, purpose now to travel over old ground, nor to reopen questions long since set at rest. We will content ourselves by observing in passing, with regard to the various theories, that the percussive force of steam alone is incapable of producing the destruction attending most steam-boiler explosions. Overheating, with which we have already dealt, cannot be assumed as the general cause, for explosions have often taken place when, but a moment before, the water-gauges indicated an ample supply of water. We have seen that a boiler has been even filled, while red-hot, with water, but no explosion took place. The electrical hypothesis, so fondly indulged in by some, is perfectly untenable, for it is impossible for electricity, if generated by ebullition or in confined steam, to collect within a boiler, which is in direct communication with the earth. That the decomposition of steam is a cause of the violence—or even of explosions at all—is negatived by the fact that the decomposition of water by heat on a large scale, for the purpose of applying its elementary gases separately, has generally been attended with very unsatisfactory results. Thus we work round to our starting point, and ask, To what cause shall be attributed the violence attending a boiler explosion? This proposition is, to our mind, most effectually met by the theory advanced by Mr. Zerah Colburn some six years since, and which subsequently formed the subject of some discussion in our columns.

In all boiler explosions, the pressure of steam is instantaneously liberated from the surface of the hot water present. Assuming the boiler to be at work at a pressure of forty-five pounds, the water will be at a temperature of about two hundred and ninety degrees. Now, fresh water cannot for an instant be maintained at a temperature much greater than two hundred and twelve degrees, under the ordinary atmospheric pressure. If, therefore, the pressure upon it be suddenly liberated, when heated to (say) two hundred and ninety degrees, a most violent disengagement of steam, and projection of water along with it, must inevitably take place. The shells of boilers are constantly liable to rupture from original unsoundness of the iron, bad riveting, corrosion by bad water, or furrowing. This being the case, what are we to expect when

the opening of a weak point suddenly liberates the steam pressure from thirty, forty or even sixty tons, of heated water, which are waiting below to burst partly into steam? To render the matter perfectly intelligible, we will state the distinct and consecutive operations into which, according to Mr. Colburn, a boiler explosion, although practically instantaneous, may be resolved. They are, first, the rupture, under hardly, if any more than, the ordinary working pressure of a defective portion of the shell of the boiler—a portion not much, if at all, below the water-line. Second, the escape of free steam from the steam-chamber, and the consequent removal of a considerable part of the pressure upon the water, before its contained heat can overcome its inertia and permit the disengagement of additional steam. Third, the projection of steam, combined, as it necessarily must be, with the water, with great velocity, and through a greater or less space, upon the upper sides of the shell of the boiler, which is thus forced completely open, and perhaps broken to pieces. Fourth, the subsequent disengagement of a large quantity of steam from the heated water now no longer confined within the boiler, and the consequent projection of the already separated parts of the boiler to a greater or less distance. This unique theory harmonizes so well with the circumstances of steam-boiler explosions, that we can but admire and accept it. It is so consistent with all the phenomena attending these explosions that it leaves no room for doubt or questioning as to its soundness. It receives support from the well-known fact that boiler explosions frequently take place at the starting of the engine, when there is a sudden withdrawal of pressure in the boiler. The most conclusive evidence of the soundness of the theory, however, would be suddenly to condense steam in the steam-chamber of a boiler at work and to watch the results. If a boiler were half filled with water, and the steam got up to thirty pounds or forty pounds, and if a quantity of water were suddenly thrown into the steam-space, the steam would be suddenly condensed, and an explosion of the boiler would doubtless follow. Such an experiment would, of course, be attended by considerable danger, and the object gained would probably, after all, be very inadequate to the risk involved. It seems to us, however, that the question has just been practically solved, and the only evidence wanting actually supplied, although under most distressing circumstances. We allude to the recent loss of the *Ceres*, in the reports of which catastrophe it is stated that the sea rushing suddenly in upon the boilers caused them to burst with fearful results. If this be correct—and all accounts agree upon the point—here is a singular though melancholy confirmation of Mr. Colburn's theory. The cold water suddenly cooled the boiler-plates, condensed the steam in the steam-space, relieved the pressure on the lower part, and forthwith the steam and water from below burst forth with resistless energy upon their errand of destruction.

From the London Engineering, No. 51.

GRINDING TYRES.

It is a fact well known to locomotive engineers that steel tyres, after they have been some time in use, become greatly hardened on their bearing surfaces, and that, in fact, a kind of hard skin is formed on them which it is frequently exceedingly difficult to remove by the ordinary process of turning. This more particularly happens in tyres which are subjected to the action of brake-blocks, as, for instance, in the case of those of tank-engines and tenders, and it has led to the manufacture of several classes of tool steel specially intended for turning them. In some cases the plan has been adopted of breaking up the hard skin of the tyres by means of a hammer having a blunt cutting-face, the cuts made by this hammer enabling the point of the turning tool to be got under the skin. This plan enables the difficulty to be got over in the greater number of instances, but the process of turning is necessarily a slow one, the speed of the lathe having to be reduced below that ordinarily employed.

During the time that Mr. (now Sir Daniel) Gooch was locomotive superintendent of the Great Western Railway, he extensively employed on that line composite tyres formed of iron faced with steel, and as the latter was hardened, it was impossible to turn them in the usual way. This led to the use of machines for grinding the tyres, and several of these machines have been successfully at work at Swindon for many years. At present their application is not confined to hard steel tyres, but they are partly employed on other tyres also, and it is probable that they will be used still more extensively. They each consist of a bed-plate carrying a pair of centres, between which the wheels, of which the tyres are to be dressed up, are placed; and they are furnished with a couple of rests, similar to those of an ordinary wheel-lathe, but each supporting a small grindstone instead of a tool-holder. These grindstones are run at a good speed by means of a simple arrangement of belting, and the wheels which are being dressed are made to turn in the opposite direction, by means of a belt passing over a pulley temporarily fixed on the axle. The grindstones can be moved either laterally or to and from the wheels, like the tools of an ordinary lathe, and the dressing up of the tyres is entirely completed by them.

In the case of tyres which could be easily turned up in a lathe, the cost of dressing them by grinding is found to slightly exceed that of turning, but in the case of very hard tyres it is considerably less. At Swindon, Mr. Armstrong is about to fit up a tyre-grinding machine with four stones, two stones being made to act upon each tyre like the tools of one of Whitworth's duplex lathes, and it is expected that by the use of this machine the cost of grinding a pair of tyres will be reduced below that of turning them in all cases. The tyre-grinding machines turn out excellent work, the finish being quite equal to that obtained in the lathe, and the correct section of tyre being accurately formed.

Although we believe that the practice of grinding tyres has been carried out more extensively at Swindon than it has been elsewhere, yet tyre-grinding machines have been used to some extent at other railway works,—for instance, at those of the London and South-western Railway at Nine Elms, those of the Great Eastern Railway at Stratford, and some of the railway shops on the Continent. Except in the case of those at Swindon, however, the use of the tyre-grinding machines has been confined in most cases to the removal of the hard skin of the tyres only, the tyres being afterwards finished in the lathes in the ordinary way. The Swindon system is much more economical, and there is every reason to believe that tyre-grinding machines of some form or other will be eventually found amongst the workshop plant of all lines upon which steel tyres are used.

From the London Engineering, No. 1, Vol. III.

BOLTS AND NUTS.

To RECOUNT the numerous ways by which the two simple and most indispensable elements of machinery—bolts and nuts—are manufactured, and the different tools used for the purpose, would occupy a volume of very considerable size, and of, perhaps, no small value to a limited number of persons. Bolt and nut making has become a large and valuable trade of itself, and many extensive works, such as the Bolt and Nut Company's works, at Smethwick, the Cleveland Bolt and Nut Works, at Middlesborough, and others, are constantly occupied in the manufacture of this speciality. The great bulk of the bolts and nuts, however, manufactured in these works for sale, are of the kind commonly called "rough," while the "finished" bolts and nuts, or those which are cut and shaped to great nicety in the thread as well as on the sides of the nut and bolt-head, are generally produced by the engine-builders who use them, engineers being as yet disinclined to entrust the accurately finished work they justly lay so much value upon, to other parties. Machines for finishing bolt-heads and shaping nuts are, therefore, an universal requisite in engineering works. One of the oldest and most successful types of nut-shaping machines has a pair of revolving cutters set to a distance apart corresponding to the width of the nut or bolt-head to be acted upon, this nut or bolt-head being passed between the cutters, either in a straight line, as in Mr. Whitworth's machines, for instance, or in a curve, as in the tools designed by the late M. Borsig, and which are still at work in his factory, at Berlin. In the exhibition of 1862, Mr. Hartmann, of Chemnitz, produced a very neatly designed machine for shaping nuts, made on the principle of a duplex slotting-machine, and this machine (the manufacture of which, in England, has been taken up by Messrs. Sharp, Stewart & Co.) was illustrated and described in this journal, at page 183 of the present volume. An excellent nut-shaping machine, and one capable of producing a large

quantity of beautifully finished nuts, is now in use at Messrs. Clayton, Shuttleworth & Co.'s works, in Lincoln, the machine being designed by their manager, Mr. Wilkinson. The nuts are screwed, in numbers of four to six, upon bolts, placed radially into a revolving head-stock, and are, in their rotation, passed first between two cutting-tools, fixed in a slide-rest, at a distance apart slightly in excess of the finished side; and then, on the opposite side, after completing half a revolution, they are operated upon by a pair of finishing tools, set so as to reduce the nuts to the exact size required. The nuts, by this process, acquire a very pretty appearance on their outer surfaces, owing to the curved tool-marks left by the action of the machine, and they are finished with great accuracy. It is said that a number of about one hundred nuts, when placed upon a table side by side and tied round with a string, can be lifted off together, and will not fall asunder when removed from the table. This, it need hardly be remarked, would be a test proving a degree of correctness and accuracy equal to the best engineering workmanship in existence. Attempts have been made to forge bolt-heads and nuts to such a nicety as to do away with tool-shaping altogether. To produce a nice, clean surface, the nuts and bolt-heads have been hammered cold, and articles of very good appearance have been produced by this process; but the iron, being operated upon at a low temperature, became brittle and crystalline, and the bolts and nuts showed the faults peculiar to that molecular structure. The brittleness of these cold-hammered bolts and nuts can be removed by subsequent annealing, but then they again lose the smooth surface; so that, practically, they are not much superior to the "rough" bolts and nuts of the trade coming from a first-class maker, and for which the name "rough" is certainly an unsuitable term, if taken at its proper meaning. Bolts and nuts, in great numbers, are cast with threads complete, by some manufacturers. Mr. E. H. Benthal, of Heybridge, casts bolts and nuts with such nicety and cleanness in the thread of both, that they fit and work into each other with an ease and correctness which cannot fail to cause some degree of astonishment. The threads are, of course, moulded from cut bolts in the first instance, and the preparation of moulds and cores requires great skill and experience; but, by practiced workmen, the work can be carried out with perfect success, and the bolts and nuts so made, can be advantageously used for many kinds of agricultural implements and machinery, or for articles of a similar nature.

The advocates of division of labor amongst engineers—and they form a very strong majority in the profession—will perhaps endorse the opinion originated by a mechanical engineer of great practical experience—that a manufactory for finished bolts and nuts, fitted out with the most improved machinery for screwing, shaping and finishing, and carried on upon the strict principle of producing nothing but the highest class of work, would be a great advantage to engineering works in general, and would find favor with engineers in the same degree as their confidence in the accuracy and good quality of the work produced should be justified by experience. The uniformity of thread introduced by Mr.

Whitworth's standard, and the great benefit derived from it by mechanical engineering at large, is, to a great extent, favorable to such a system of manufacture, and would enable works laid out for it to keep a stock of all standard sizes of finished bolts and nuts, which might be supplied cheaper, and, if not better, certainly as well finished as in the best machine-shops existing. Their manufacture, when thus carried out on a large scale, would receive more of the undivided attention of practical men than can be bestowed upon this single subject in large works, where it forms only one of the numerous accessories of the general business, and has to be carried on, so as to least interfere with the main bulk of the work.

From the London Engineering, No. 29, Vol. II.

ROAD TRACTION ENGINES.

With the change of Ministry there is every probability of a relaxation of the obstructive and mischievous legislation on steam traction engines. For these there is a large and increasing demand, since by means of them, work can be done at half the cost of horse-power. The first of a number of traction engines required by the Ottoman Carrying Company has recently been turned out by Messrs. Dübs & Co., Locomotive Works, Glasgow, to the designs of Mr. D. K. Clark, C.E., embracing the Bray driving-wheel and many points of novelty which have been protected by patents. The engine is intended for service in Syria, between Damascus and the port of Beyrout, a journey of sixty-eight miles, across Mounts Lebanon and Anti-Lebanon, and is to carry ten tons of goods over steep inclines of one in twelve, and others scarcely less steep, at the rate of from three to five miles per hour. This engine differs in several important particulars from the ordinary construction of traction engines. These have for the most part been made, as a *sine quâ non*, cheap, after the model of the common portable engine, for agricultural purposes, combining the means of occasionally taking a load across a field or along a country road, with the means of driving machinery. But in the new engine, which is supported on bearing springs, a strong frame is constructed expressly to carry the boiler and the whole of the machinery, also to bear all the stress and fatigue incidental to the hauling of heavy loads on common roads. By means of a compact differential motion, the engine is enabled to turn the quickest curves, with a train behind it, with the greatest facility, the outer driving-wheel being, by self-acting means, enabled to revolve faster than the inner one, as in an ordinary carriage or wagon. Thus, the whole tractive power of the engine is available in turning the curves, getting rid of the stress and loss of power caused by the inevitable slipping and grinding of engines not so fitted. The machinery is arranged horizontally beneath the boiler, and thus a

very simple and compact system of framing has been matured. The Bray teeth, which are applied to the driving-wheels, are formed hollow, so as to receive the thrust of the teeth-rods inside, and thus to avoid the tilting action of a thrust on end. By means of these and other specialities, Mr. Clark has endeavored to combine great strength and lightness with efficiency and durability; at the same time the cost is moderate. The engine carries five hundred gallons of water and fifteen hundred-weight of coal, and when tested with the regulation load of ten tons, carried in two wagons over the steep inclines of the Cathcart Road, near Glasgow, she ran at an average speed of four and a half miles per hour, going and returning, the prevailing gradient being one in thirteen and a half, on a macadamized surface. The maximum speed was about six miles per hour, equal to that of a London four-wheeled cab. The engine has been solidly constructed of the best materials and workmanship, and has been beautifully finished, to the great credit of the young, but already celebrated, firm of Messrs. Dübs & Co. This, the first traction engine constructed for the Ottoman Company, is named the *Abdul Aziz*.

HYDRAULIC RAM OBSERVATIONS,

FOR USEFUL EFFECT.

Observations by Gen. H. Haupt, Oct. 10, 1866,—Chestnut Hill.

Reduced and compared by Henry Cartwright, Esq.

Head of water to Ram, 8·812 feet.

Discharge of water per minute, 768 cubic inches = 3·31 gallons of 231 cubic inches = 27·73 pounds.

Diameter of drive-pipe, $1\frac{1}{2}$ inch × 15 feet long.

Diameter of delivery-pipe, $\frac{3}{4}$ inch × 200 feet long.

Horse-power of water to Ram, ·0074 = $\frac{1}{1350}$ horse-power,

$$(27{\cdot}73 \times 8{\cdot}812 = \frac{244{\cdot}35}{33{,}000} = {\cdot}0074 \text{ horse-power.})$$

Height of delivery, 63·4 feet.

Delivery per minute, 48 cubic inches = 1·736 pounds.

Delivery per five minutes, 1 gallon.

Strokes of Ram per minute, 170.

1·736 pounds × 63·4 feet = 110·06 pounds, one foot high,
27·73 pounds × 8·812 feet = 244·35 pounds, one foot high, } the effect produced is ·45 per cent. of power expended.

Mechanics, Physics and Chemistry.

THE HOLTZ MACHINE.

A SIMPLE, CHEAP AND EFFICIENT FORM.

By H. Morton, Ph.D.

As has been mentioned in a previous number of this *Journal*, the Holtz machine, manufactured by Ruhmkorff, and secured for me at a very early period by Mr. James Swaim, now resident in Paris, after working in a very satisfactory manner for some weeks, suddenly gave out and failed to produce any useful effect.

A series of experiments, which followed, served to demonstrate that this failure resulted from a loss of insulation in the edges of the paper strips attached to the fixed plate. And this fact, together with its remedy, (found in giving the papers extra insulation at their edges,) was published in this *Journal*, page 421, Vol. LII.

At that time the expedient of turning the plate around, so as to have the papers on the outside, and thus secure the glass plate itself as a means of insulation, was tried, but not found satisfactory, owing, as is now believed, to accidental causes, such as dampness, hasty adjustment &c. The result obtained was however, so little excellent that all thought of adopting such a method was abandoned.

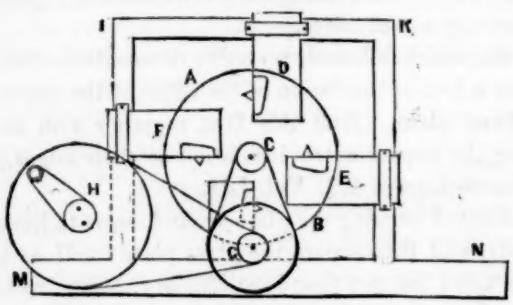
A few days since, however, in showing the machine to Mr. Robert Briggs, I set the plate in this way to illustrate certain actions, and the weather being very dry and adjustment good, found the effect far better than was expected; in fact *so* good, that the machine was run for a long time and with great satisfaction, in this way. We can therefore recommend this plan for adoption whenever a machine loses effect by leakage. If the fixed plate is reversed and adjusted as close as possible to the other, all the quantity effects can be obtained as before, the length of spark only being shortened somewhat.

On the same occasion, while discussing with Mr. Briggs the theory of this machine and the modifications of M. Bertsch, this gentleman proposed to abandon the fixed plate and substitute for it four plates of vulcanite, supported in a frame, which he sketched on the spot, and proposed to have made and send to me as soon as possible. In due course the frame arrived, and pending the preparation of the vulcanite

strips, which were not ready, I arranged four plates of glass, such as I use for drawings in the lantern, with strips of paper such as are found in the ordinary Holtz machine. These I supported in the frame opposite the collecting points, and much to my satisfaction, found the machine in this *cheap* form to work with quite as great effect as in the delicate and costly construction with the five-windowed plate of glass.

This result was naturally to have been expected, the office of the glass plate being merely to afford an insulating mechanical support to the paper strips, (according to the theory of the machine which I have before published).

The exact method of arrangement is indicated in the accompanying figure, where I, K, M, N represents the supporting frame, and F, D, E, C the glass plates; while the revolving glass disc is shown at A, C, B, and the pulleys and crank, to give it motion, at CC and H.



The advantages of this form are manifest, including cheapness of construction, ease of transportation and repair, capacity of modification; two, three or four elements, or a larger number, being easily applied or removed, as occasion requires. By placing the papers on the outside of the glass, the great difficulty of securing thorough insulation to their edges is removed, and a few coats of varnish, hastily applied, render them efficient.

HOW TO SELECT LUBRICATING OILS.

In selecting sperm oil for fine machinery, a small quantity should be poured on a polished steel plate. If it corrodes the plate, as some samples will, it should not be used. There is sometimes a trace of acid in the oil. . . .

Translated for the Franklin Institute Journal from the Comptes Rendus, Vol. LXIII., p. 881.

A FURTHER MODIFICATION OF THE HOLTZ MACHINE.

By M. A. Piche. Communication by M. de Parville.

In the *Compte Rendu* of November 5th, M. Bertsch gives a description of a new electrical generator or continuous electrophorus. I also have described, in several journals, on the 21st of January last, an apparatus which appears to me similar to that of M. Bertsch. The inventor, M. A. Piche, has published a note on the subject, with a drawing to explain it. I now have the honor of showing this, to the Academy.

M. Piche discovered his rotating electrophorus in trying to simplify M. Holtz's machine. I here give a concise description of it:

A single disc of strong paper, thirty centimetres in diameter, is mounted on an axle of isolating material, a glass tube for example, that is caused to rotate between convenient supports, by means of a handle and two pulleys with an endless band. In front of the disc there are two collectors with metallic points, symetrically placed with regard to the centre. These copper wires, which are at first perpendicular to the plane of the disc, turn at the ends vertically, one towards the bottom, the other towards the top, so as to approach each other, and they terminate in two movable balls.

To charge the apparatus, you take a piece of paper which has been well dried by the fire, and rub it; then place it at the opposite side of the disc. You then rotate the disc, and you will perceive between the two balls a luminous jet, the sparks of which are continuous, and give out ozone.

By covering the disc with shellac, and placing in front of the second collector, another piece of paper charged with opposite electricity to the first, it produces more intensity in the experiment, and causes it to last longer. You obtain with this rudimentary apparatus sparks of five centimetres in length, when the experiment is successfully performed.

If you connect the two balls with the armatures of a Leyden jar, the jar is rapidly charged, and if you bend the copper wire so that the jar will discharge itself, you can obtain forty discharges without rubbing the paper again.

It is only necessary to compare this short description with that of M. Bertsch, to be convinced that the two pieces of apparatus are similar, having the same principle and the same result.

M. Bertsch writes: "A disc, formed of a sheet of isolating material, is mounted on an arm of the same material, and can be turned by a handle or treadle, with the rapidity of ten or fifteen turns a second. Two collectors with metallic points and without communication between them, are placed perpendicularly to the plane of the plate, and serve to exhibit the double current which is created." And further on: "Behind the plate, and parallel to its plane, you can place, if desired, one or many sectors, or thin sheets of isolating material, not in contact with the last, but at a short distance from it," etc. "To start the machine, it is sufficient to rub one of these sectors very lightly with the hand, which excites its surface, and to place it in the indicated position; the wheel then being put in motion, a series of sparks springs between the two electrodes without interruption," etc.

M. Piche constructed his machine, with a trifling cost, with paper, glass tubes, corks and copper wires. M. Bertsch has made a scientific instrument, but it appeared to us that it was not without interest, nor even without importance, to enter into these details of the other apparatus.

From the London Journal of the Society of Arts, No. 689.

(Continued from page 46).

CANTOR LECTURES—SUBMARINE TELEGRAPHY.

By Fleeming Jenkin, Esq., C.E., F.R.S.

But although from these tables it appears that the Atlantic cable might be lifted by sheer pulling, this course is not advisable owing to the extra strains produced by the heave of the ship, the resistance to displacement by the water, the friction of the water, possible currents of water, the possible drift of the ship to one side of the cable, and the possible existence of a weak point in the cable. Owing to all these elements the practical chances of success by sheer pulling are very small. It has been proposed to lift the cable by a number of ships, acting like so many piers to a suspension-bridge. It is difficult to suppose that they would keep their respective positions accurately, or all haul in at the proper rate. It has also been proposed to catch the cable at one point, then at another nearer the end, then to drop the first grapnel, and catch the cable

again nearer the end, and so, working hand over hand, reach a point at last so near the end that the cable could be lifted nearly vertically. This is better than the last plan, but is unnecessarily complicated, and the cable might easily be injured in the attempts to catch it at so many points. The simple plan which at once occurred to all practical men, is to catch the cable with one ship by holding grapnel, and then to cut it with a grapnel from a second ship, some three miles to seaward; the loose end held by the first ship could then be hauled on board with little strain. This plan will probably be adopted, with much chance of success. It is certain the cable *was* caught, and probably it can be hooked again; if so, there should be no difficulty in raising it, unless it is rusted to a much greater extent than we have any reason to expect. The grapnel of the first ship should be a holding grapnel, of which several models were shown, otherwise the loose end might fly back over it if the second ship cut too near the first. The second ship should have a cutting grapnel, of which models were also shown, lest if the attempt were made to break the cable by brute force it might break at an inconvenient point. Mr. Latimer Clark's grapnel, which would answer either of these purposes, was exhibited. The cable when hooked, releases a catch, allowing a block, to which the grapnel rope is attached, to be hauled up the shank, pulling round two right and left hand screws by two steel bands; the screws close the jaws which grip the cable or cut it; or one grapnel may be made both to cut and grip the cable. The grapnel can lie in only two positions, and if dragged in the proper direction, cutters placed at two diagonally opposed corners would cut the cable certainly to seaward, and the jaws hold the landward end. A simple form of holding grapnel, conceived by Mr. Carpmael, Jr., was shown; in this the cable is jammed between the prongs and a kind of half bollard. A holdfast or cutting grapnel, designed by the lecturer, was also shown. Each prong is hinged on a pin projecting beyond the shank, and the prong is so shaped at the root that the cable, when on it, closes the prong tighter and tighter on itself, whereas the end of the prong, when dragging through sand or mud, is opened like a Trotman's anchor.

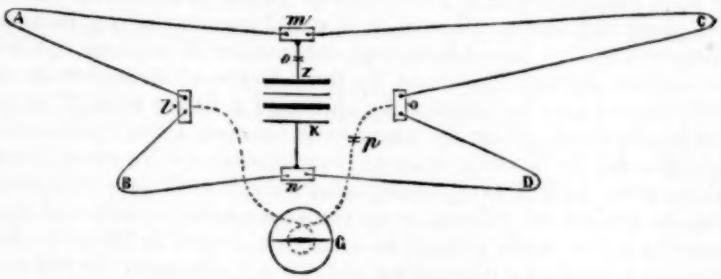
LECTURE IV.—ELECTRICAL TESTS.

1. *Terms used.*—In order to understand electrical tests, it is chiefly necessary to have a definite conception of what is meant by electrical resistance. When the two end-plates of a voltaic battery are joined by a wire or other conductor, an electric current flows through the conductor, the presence of the current being shown by the power the wire has acquired of deflecting a magnet in its neighborhood. The magnitude of a current is simply proportionate to the force with which it acts on a magnet (*cæteris paribus.*) Thus, a magnet hung inside a coil of insulated wire, is called a galvanometer, or current measurer, since it may be said to measure the current by the deflection of the magnet. When this deflection is small, as was the case with the instruments exhibited, in which the deflection of the magnet was indicated by the

motion of a reflected ray of light, the deviations of that ray of light, from its normal position, may be considered as true relative measurements of the current producing that deviation. The battery may be looked upon as a constant source of power, and the conductor as a kind of pipe conveying the current of electricity. The magnitude of the current depends, with a given battery, on what is called the resistance of the circuit. If the wire be small and long, the current will be feeble, and the resistance of the circuit is said to be great. If the wire be short and thick, the resistance will be small. The resistance of a conductor is the property in virtue of which it prevents a given battery from producing more than a given current, precisely as the resistance of a pipe to the passage of water might be defined, as the property in virtue of which it prevents the passage of more than a certain current of water with a given head. The resistance of conductors varies, not only with the dimensions, but with the materials of which the conductor is composed; and this resistance can be measured, *i.e.*, compared with the resistance of any other given wire, in virtue of Ohm's law, viz: that the current through a given circuit is inversely proportional to the resistance, and directly proportional to the force producing it. That force is constant with a given battery, so that if we find our current halved by the introduction of a certain wire into a circuit, we may be sure that the resistance of the circuit is doubled; but in making that calculation we must take into account the resistance, not only of the wire, but of the measuring instrument and of the battery. When this is done the old distinctions of quantity and intensity currents will be found unnecessary, and, indeed, false, since a current has but one measurable property, viz: its magnitude or strength. A current existing in a circuit which already includes a considerable resistance, is what used to be called an "intensity current." A current in a circuit which includes no considerable resistance, is what used to be called a "quantity current." The first is little affected by the addition of a resistance which may almost wholly annihilate the second. A convenient method of measuring the resistance of a battery, due to Professor Thomson, is given in Appendix II. By the simple application of Ohm's law, we might compare the resistances of two wires by observing the relative effect which they produce in a given circuit; but this is inconvenient, and hardly admits of such accuracy. The battery may vary, both as to force and resistance, during the two tests, and even if constant, the accuracy of the observation will be limited by the accuracy with which a deflection can be observed. More accurate practical tests have, therefore, been invented to measure and compare the resistance of conductors.

Tests of Conductor.—Every test used is a test of resistance, and all depends upon Ohm's law above cited. The instruments may be much varied, but the most convenient is probably that known as "Wheatstone's Balance or Differential Measurer. Let four wires be joined with a galvanometer and battery, as in Fig. 1. Then, if A, B, C and D represent the resistances of the four wires, no current whatever will

pass through the most sensitive galvanometer when $\frac{A}{B}=\frac{C}{D}$; but if the ratio $\frac{A}{B}$ be a little larger than $\frac{C}{D}$, a current will pass through the galvanometer in one direction. If $\frac{A}{B}$ be smaller than $\frac{C}{D}$, the current will be in the opposite direction. An explanation of this fact will be given in the ensuing lecture. Four wires thus arranged allow us to measure the resistance of any one of them which is not known, in terms of the three others: If A and B are equal, we may try how great a length of D is exactly equal in resistance to C, a selected standard, and this is precisely the test adopted to choose copper of small resistance or good conducting power. C is, say one hundred inches of copper wire, known to be good. Then the observer tries how great a length of copper wire from a new hank must be inserted at D to bring the galvanometer to zero, or no deflection. If this length be one hundred and five inches, the new hank is five per cent. better in quality than the standard. If the length be ninety-five inches, then the new hank is five per cent. worse in quality than the standard. But this is not all. If we desire



to measure a coil of wire having ten times the resistance of C, we may make B exactly ten times A, and then when we have adjusted the length of the wire D, so that the galvanometer is at zero, we may be sure that the resistance of D is ten times C. Hitherto we have spoken of comparing two random wires; but it will clearly be convenient to have some common term of comparison, such as the foot for length, or the pound for weight. With this view the resistance of a certain piece of wire is chosen as the unit, and when other wires are measured, instead of being always directly compared, they are each compared with the unit, and are said to have each so many units of resistance. Several units have been proposed. The lecturer uses that known as the British Association unit, sometimes called the "Ohm." When a unit has been chosen, whether for length, weight or electrical resistance, it will always be found convenient to have multiples of the unit for measuring large quantities and fractions of the unit for comparison with small quantities. With this object separate pieces of wire, equal

to 1, 2, 3, ... to 1000, or even 10,000 units, are prepared in cases, and conveniently arranged, so that any resistance required can be selected and inserted in the required circuit. These cases of graduated wires are called sets of resistance coils, and are variously arranged by the different makers. Mr. C. W. Siemens and Messrs. Elliott Brothers, both make sets of British Association coils. If, when possessed of such a set of coils, we receive a wire of which we do not know the resistance, we may arrange a Wheatstone's balance, in which two equal coils are connected, as at A and B. The new wire at D, and the set of coils at C. We then find by trial the number of units required to bring the galvanometer to zero. If we find D too small to be conveniently measured thus, we may choose two coils equal to 1 and 100 for B and A. When the galvanometer is at rest, on completing the circuit, the resistance of D will be the hundredth part of the coils included at C. Similarly, if D be large we may make the coil A 1, and B 100; then the resistance of D will be one hundred times that of the coils required at C to bring the galvanometer at zero. A still greater degree of precision in comparing C and D will be obtained if part of the wire between A and B be a uniform wire laid along a measured scale, and if the point *l*, to which the galvanometer wire is attached, be made movable along this wire, the resistance of which must be known as compared with the other parts of A and B. Now, if A, B, C and D are as nearly balanced as they can be by the addition and subtraction of units at C, a still more perfect balance (indicated by the absence of deflection in the galvanometer) may be obtained by shifting *l* a little; then, if its position be observed, giving the exact ratio between A and B, the exact value of D can be found in terms of the unit used at C by a simple-rule of-three-sum. In fact, every change that the rule of three is susceptible of can be worked out effectually by the above arrangement, and measurements can be made without an error of one part in 100,000. Experiments were shown illustrating the above statements. It will now be seen that we have the means of comparing the resistance of wires very accurately, and of comparing all wires with a common unit; but it is also convenient to be able to calculate beforehand what the resistance of a given wire will or ought to be, and for this purpose it will be sufficient to know the resistance of some one wire of known dimensions of each material. The resistance of all other wires of that material can then be simply calculated, since that resistance is directly proportional to the length, and inversely proportional to the section, of the wire. Table IX. is a table of "specific resistances," defined in various ways. The first column contains the numbers which will probably be found most useful. The following is an example of its use: Let it be required to know the resistance at 0° of a conductor of pure hard copper, weighing four hundred pounds per knot. This is equivalent to four hundred and sixty grains per foot. The resistance of a wire weighing one grain per foot is 0·2106; therefore, the resistance of a foot of a wire weighing four hundred and sixty grains will be $\frac{0{\cdot}2106}{460}$,

but the resistance of one knot will be 6087 times that of one foot; hence the resistance required will be $\frac{6087 \times 0{\cdot}2106}{460} = 2{\cdot}79$ units. If

TABLE IX.—*Specific resistance in* B A *units of metals and alloys at 0° C., from Dr. Matthiessen's experiments.*

Name of metals.	Resistance of a wire one foot long, weighing one grain.	Resistance of a wire one metre long, weighing one gramme.	Resistance of a wire one foot long, $\frac{1}{100}$th inch in diameter.	Resistance of a wire one metre long, one millimetre in diameter.	Approximate per centage of variation in resistance per degree of temperature at 20°.
Silver annealed.....	0·2214	0·1544	9·936	0·01937	0·377
" hard drawn....	0·2421	0·1689	9·151	0·02103	.....
Copper annealed.....	0·2064	0·1440	9·718	0·02057	0·388
" hard drawn...	0·2106	0·1469	9·940	0·02104	.....
Gold annealed.....	0·5849	0·4080	12·52	0·02650	0·365
" hard drawn.....	0·5950	0·4150	12·74	0·02697	.....
Aluminium annealed.	0·06822	0·05759	17·72	0·03751	.....
Zinc pressed.....	0·5710	0·3983	32·22	0·07244	0·365
Platinum annealed....	3·536	2·464	55·09	0·1166	.....
Iron annealed.....	1·2425	0·7522	59·10	0·1251	.....
Nickel annealed.....	1·0785	0·8666	75·78	0·1604	.....
Tin pressed.....	1·317	0·9184	80·36	0·1701	0·365
Lead pressed.....	3·236	2·257	119·39	0·2527	0·387
Antimony pressed	3·324	2·3295	216·0	0·4571	0·389
Bismuth pressed.....	5·054	3·525	798·0	1·689	0·354
Mercury liquid.....	18·740	13·071	600·0	1·270	0·072
*Platinum silver, alloy hard or annealed.....	4·243	2·959	148·35	0·3140	0·031
†German silver, hard or annealed....	2·652	1·850	127·32	0·2695	0·044
‡Gold silver alloy, hard or annealed....	2·391	1·668	66·10	0·1399	0·065

the diameter of the wire be given instead of its weight per knot, the calculation is still simpler, and the constant for English measures would be taken from the third column of the table. Thus, the resistance at 0° of a knot of pure hard drawn copper wire 0·1 inch diameter, would be $\frac{6087 \times 9{\cdot}94}{100^2} = 6{\cdot}05$. It will be seen that annealing wires materi-

* The alloy used for B A resistance units, two parts platinum, one part silver by weight.

† The alloy commonly used for resistance coils.

‡ Two parts gold, one part silver by weight.

ally alters their resistance, though it leaves their chemical composition quite unaltered. A rise in temperature increases the resistance of all the metals, and Dr. Matthiessen discovered that for all pure metals the increase of resistance between 0° and 100° C. is sensibly the same

TABLE X.—*Constants, for metals or alloys, by which to calculate the resistance* R *at temperature t from the resistance r at zero:* $R = r(1 + a t \pm b t^2)$.

	a.	*b.*
* Pure metals	0·003824	+ 0·00000126
Mercury	0·0007485	— 0·0000003398
German silver	0·0004433	+ 0·000000152
Platinum silver	0·00031	.....
Gold silver	0·0006999	— 0·000000062

TABLE XI.—*Resistance in* B A *units of wires one foot long, weighing one grain.*

Temperature, Centigrade.	Soft copper.	Hard copper.	German silver.†	Platinum silver.‡
0	0·2064	0·2106	10·61	16·97
5	0·2102	0·2147	10·628	17·00
10	0·2144	0·2188	10·647	17·02
11	0·2153	0·2197	.....	.....
12	0·2161	0·2205	.....	.....
13	0·2170	0·2214	.....	.....
14	0·2178	0·2222	.....	.....
15	0·2186	0·2231	10·665	17·05
16	0·2194	0·2239	.....	.....
17	0·2203	0·2248	.....	.....
18	0·2211	0·2256	.....	.....
19	0·2220	0·2265	.....	.....
20	0·2228	0·2272	10·682	17·08
21	0·2237	0·2283	.....	.....
22	0·2242	0·2288	.....	.....
23	0·2253	0·2299	.....	.....
24	0·2262	0·2308	.....	.....
25	0·2271	0·2317	10·702	17·10
26	0·2279	0·2325	.....	.....
27	0·2287	0·2334	.....	.....
28	0·2296	0·2343	.....	.....
29	0·2305	0·2352	.....	.....
30	0·2313	0·2360	10·720	17·13
31	0·2322	0·2369	.....	.....
32	0·2328	0·2375	.....	.....
33	0·2340	0·2388	.....	.....
34	0·2348	0·2396	.....	.....
35	0·2357	0·2405	10·739	17·15
36	0·2365	0·2413	.....	.....
37	0·2376	0·2424	.....	.....
38	0·2383	0·2432	.....	.....
39	0·2391	0·2440	.....	.....
40	0·2400	0·2449	10·757	17·18

* Approximate or mean formula. † Calculated from specific gravity 8·47.

‡ Calculated from specific gravity 12·0. (Approximate values only.)

except for iron. Table X. gives the formula and constants by which the resistance of any wire between those limits may be calculated. Roughly, all pure metals increase from 0·37 to 0·39 per cent. for each degree of temperature within the limits usually occurring in rooms. Table XI. gives the specific resistance of the more important metals at various temperatures. The resistance of most alloys is very much greater than the mean of the metals composing them. Indeed, a singularly small mixture of a foreign metal reduces the resistance of the pure metals very largely; so much so, that in commerce copper cannot be obtained which is equal, or even nearly equal, to that of pure copper. The figures and constants given in the above tables are only applicable with accuracy to pure metals. In old cables the quality sometimes was very bad; but lately the resistance of cable-copper has usually been only about ten per cent. more than that of pure copper. Table XII. gives the resistance of the copper of various cables at 24° C.,

TABLE XII.—*Resistance per knot and specific resistance in* B A *units of conductors and insulators of various cables at* 24° *C.*

Name of cable.	Resistance per knot of conductor at 24° C.	Specific resistance of foot grain at 24° C.	Resistance per knot of insulator at 24° C., after one minute's electrification.	Specific resistance of insulator, or resistance of one foot cube, at 24° C., after one minute's electrification.
Red Sea	7·94	·2700	28×10^6 to 38×10^6	$0{\cdot}875 \times 10^{12}$ to $1{\cdot}187 \times 10^{12}$
Malta-Alexandria, mean	3·49	·2637	115×10^6	$4{\cdot}06 \times 10^{12}$
Persian Gulf, mean	6·284	·2469	193×10^6	$5{\cdot}910 \times 10^{12}$
Second Atlantic, mean	4·272	·2421	349×10^6	$11{\cdot}22 \times 10^{12}$
Hooper's Persian Gulf core, mean	.....	.....	8000×10^6	245×10^{12}

also the specific resistance at the same temperature. Although alloys cannot be used for cables, owing to their high resistance, they are very useful in the construction of resistance coils, since not only are coils of great resistance made of small bulk by their use, but these coils are much less altered by a change of temperature than if made of simple metals. The tables contain the resistances of the chief alloys now in use, with the co-efficients for temperature corrections. There are many points of great practical importance in measuring the resistance of conductors, which cannot be here fully treated of. Thus, all resistance coils should be wound double, so that the current may pass both ways round the coil equally; this prevents self-induction—a disturb-

ing element. Care must generally be taken in using the Wheatstone balance to connect first the battery at *o*, (Fig. 1,) and then the galvanometer at *p*. The battery must be left connected for the shortest possible time to avoid heating the wires; special precautions must be taken to avoid resistances at connections, which are often considerable. The resistance of the wires composing the balance should not differ too greatly from that to be measured; short wire galvanometers answer best for short wires; long wire galvanometers for long wires;—one cell of large surface generally gives better results than large batteries. The temperature of the wire to be measured, and that of the resistance coils, should be accurately observed. These and many other points could only be fully developed in a treatise on testing. Practically, the copper of a cable is tested before it is used, to ascertain whether its quality is equal to that specified. When a knot of wire is covered it is again tested for resistance, to ensure that the proper quantity and quality of wire has been used; finally, after the cable is covered, the resistance test serves to check the length of the cable in circuit, to ensure that the conductor is at no point interrupted, and that the temperature in the tank is not higher than it should be.

(To be continued.)

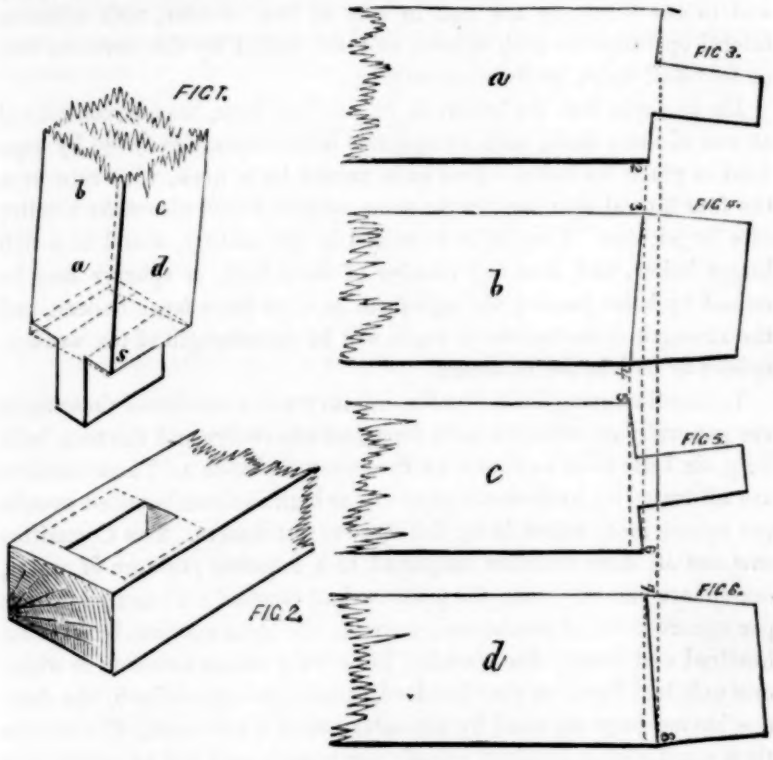
For the Journal of the Franklin Institute.

METHOD OF FRAMING A DOUBLE BATTERED POST.

By Alfred P. Boller, C. E.

Among the many interesting details of framing to be met with in carpentry, that of framing a post into a sill, so that the post will batter in two directions, is perhaps the most difficult, and but few carpenters are able to do it. The accompanying plate gives all lines that are required to scribe out such a piece of work, and can readily be understood. Fig. 1 shows an isometrical view of the foot of a post with its tenon, and Fig. 2 the ordinary mortise in the sill to which it is to be attached. Figs. 3, 4, 5 and 6 represent all four sides of the post, and for convenience of illustration, is drawn to a scale of one-twelfth its real size, the batter being one inch to the foot. The construction is as follows: Starting from the corner one, Fig. 3, (corresponding to the corner s, Fig. 1,) draw 1–2 an inch from the vertical, making the tenon perpendicular to it. This gives the face *a*. The face *b* is formed by projecting 2 to 3, and drawing 3–4 an additional inch from the vertical, and the tenon parallel to this new line. The point 4 is now two inches from 1, and is half-way around the post. Now batter

each of the remaining two faces in a reverse direction, until the point 8 is reached, which coincides with the starting point 1. We have thus traveled around, as it were, each face of the post, and scribed out the shoulders of the tenon.



Report of the Committee on Science and the Arts, constituted by the Franklin Institute, on the Harrison Steam Boiler.

Invented by Joseph Harrison, Jr., Philadelphia, Pa.

The Committee to whom was referred the examination of the "Harrison Boiler," report that, on Tuesday, October 30th, they visited the foundry of Mr. Joseph Harrison, Jr., Philadelphia, and had an opportunity of inspecting the boilers in various stages of manufacture, and of seeing several in operation.

Experiments were tried to prove the strength and durability of the boiler under extraordinarily severe use.

The boilers are of cast iron, formed of a combination of hollow spheres each eight inches diameter externally, and three-eights of an inch thick, connected by curved necks three and a quarter inches diameter. These spheres are held together by wrought iron bolts, and in one direction are cast in sets of two or four, with opposite lateral openings to each sphere, and are called by the inventor two or four-ball units, as the case may be.

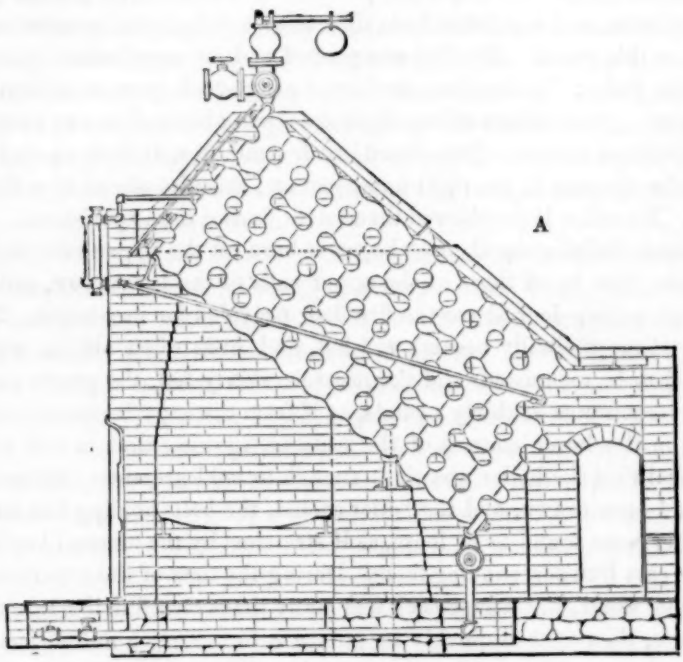
He assumes that the boiler, in its smallest form, may be considered as one of these balls, with its opposite lateral openings closed by caps held in place by bolts. Two balls united by a neck, with caps over the four lateral openings, in the same manner would also make a boiler of a larger size. Four balls so united in one casting, would be a still larger boiler, and that any number of these balls or spheres may be united by bolts passing through them so as to form large boilers, and the strength of the boilers so made will be the strength of the weakest sphere or ball in the structure.

In manufacturing the boiler for ordinary use, a number of these units are generally so arranged as to form sections twelve and thirteen balls long, six balls wide, as shown by the annexed sketch A. These sections are all tested by hydrostatic pressure as high as three hundred pounds per square inch, before being delivered to purchasers. The Committee saw one of these sections subjected to a bursting pressure of water, one sphere bursting when the pressure had reached six hundred pounds per square inch. A second one, tested in the same manner, burst at six hundred and twenty-five pounds. They were shown a section in which one unit had burst at nine hundred pounds per square inch, the damage having been repaired by the insertion of a new unit. The section then stood eleven hundred pounds per square inch before bursting in a new place. The available strength of the section in all cases being the strength of the weakest unit in it, the inventor holds that the boiler is safer than any other in use; in fact, considers it entirely free from any danger of disastrous explosion. To prove which, he had a section equal to six horse-power, similar to the one tested by hydrostatic pressure, and such as he is regularly selling, placed in an extemporary furnace built in a clay-bank, and set the usual manner for a boiler of this kind.

The boiler was filled with water to the regular height, say about two-thirds full, with no outlet or safety-valve of any kind, and sealed up tight, a small tube leading from the upper ball to a high pressure-gauge, placed at a safe distance, about two hundred feet, from the boiler. A fire

was made under and around the boiler, with the fuel of dry pine wood. The wind was very high at the time of the experiment, blowing from the west directly into the furnace, thus fanning the flames to an intense heat.

The gauge soon gave indication of the formation of steam, the pressure steadily increasing up to four hundred and fifty pounds to the square inch.



At this pressure there seemed to be a sudden discharge of steam, as from a small opening. The discharge did not continue for many seconds, and the Committee are not certain that it proceeded from the boiler; there may have been some water discharged from the bank of wet earth into the fire. The pressure then increased at an uniform rate until it had reached the enormous strain of eight hundred and seventy-five pounds per square inch, when a sudden discharge of steam took place, seemingly no greater in volume than might issue from a safety-valve of two and a half inches diameter, or even less; after which the pressure fell to four hundred and fifty pounds, at which it stood when the fire was drawn for examination. While this boiler was being

uncovered for examination, a boiler of about twelve horse-power, consisting of two sections, similar to the ones previously experimented upon, was fired, and steam raised to one hundred and twenty-five pounds pressure. This boiler had no safety-valve, but was provided with a globe-valve of one inch capacity or area, as an escape-valve to regulate the pressure in the boiler. When the Committee examined this boiler at time of firing, it had two full gauges of water. The escape-valve was opened so as to reduce the pressure to one hundred pounds per square inch, and regulated from time to time to keep the pressure uniform at this point. The fire was pushed and no more water injected into the boiler. In due time the lowest gauge-cock gave no indication of water. Soon afterwards a slight leak was observed in one joint of the left-hand section. This closed in a few minutes, and one opened in a similar manner in the right-hand section; this also closed in a short time. No other leaks showed themselves during the experiment. As the water boiled away the soot began to burn off the upper balls of the sections, that is, off those of the upper balls of the lowest row, visible through a peep-door above the fire-door provided for inspection. The boiler then gradually became red-hot, and even when all the water seemed to be exhausted, and the pressure slowly fell, the gauge stood for some minutes at thirty pounds, as if from the vaporization of some water in the lower courses of the sections, showing that in this red-hot condition the boiler was tight enough to hold pressure. After the fire had been drawn, and the boiler cooled, the bolts holding the units together were found to be loose, as if stretched by the unusual heating of the cast iron surrounding them. During the time of the experiment with low water, the escape-cock was many times closed to increase the pressure, then opened quickly to reduce it to the one hundred pound standard, but with no deleterious result. When the gauge stood at thirty pounds, all of the boiler visible from the peep-door and fire-doors, down to the bridge-wall of the furnace, was at a bright red heat. This was unmistakable, as when the fire was drawn, the boiler was hot enough to ignite wood held against it.

November 13*th*, 1866.—At four o'clock, P.M., the Committee met at the factory. J. Agnew and J. C. Cresson, present. They examined the boilers tested at the former meeting. The boiler which had been subjected to its own steam-pressure of eight hundred and seventy-five pounds per square inch had been removed to the factory for examination. Mr. Harrison's foreman stated that when the boiler was first dragged from the fire, after its water had been forced out, (as

detailed in the account of the experiment, the three lower bolts were quite slack, but the next morning, when it had become cold, one of them was again tight. The other two were not quite tight, but were then screwed up about one turn of the nuts. The Committee are confirmed in their belief that in this extreme test, the pressure at eight hundred and seventy-five pounds was enough to stretch some of the bolts, that the joints opened as safety-valves, and thus relieved the strain on the boiler.

The boiler which, in former experiments, had had all its water boiled out, and had then been heated to bright redness, was found to be quite sound and fit for use, making steam freely and showing no leak, blowing off at sixty-five pounds by safety-valve. It was somewhat disfigured on its outside by oxidation. Your Committee was informed that it had not been changed or repaired since the trial, but that some of the bolts had been screwed up.

A third boiler of the same size as the above, twelve horse-power, was then tested in the following manner: After being filled with water to the upper water-line, it was fired until pressure was raised to ninety pounds, at which it was blowing-off freely. The water was then all blown out by the blow-off cock, the pressure falling to sixty pounds while blowing-off, at which it stood until steam reached the blow-off pipe, when the pressure fell to zero. It was kept empty for three minutes, with the fire still burning, and was then rapidly filled with cold water, and steam raised to one hundred pounds pressure in thirty minutes, blowing off at one hundred pounds, and was quite sound and tight.

The Committee was informed by one of its members, who was a witness of, and cognizant of, all the facts, that at the establishment of Mr. Wm. Sellers & Co., of this city, a boiler of this kind has been in use for about two years. During some experiments in testing the Giffard Injectors made by that firm, a workman inadvertently loosened a connection to the water supply-pipe, resulting in the pipe blowing full open, discharging the water from the boiler as fast as a two-inch diameter opening would allow, the men in the boiler-room barely escaping with their lives. As soon as all the water had blown off, and access could be had to the boilers, the fires were drawn and cold water run in as fast as possible, and in about thirty minutes, the steam was high enough to run the engine, with no seeming injury to the boilers.

The Committee mention this as an accidental experiment, similar to the one above reported. The same boiler is still in use, and seemingly

as good as when first erected. It is, however, the first one erected in this country from units made in England, and is not so good as those made since then. On Saturday, November 17th, Mr. Harrison repeated an experiment in the presence of a part of the Committee, Messrs. Agnew, Morton and Sellers, which experiment he stated had been tried twice the day before, and once two days previous, all the experiments being with the same boiler. The experiment, as witnessed, was as follows:

The boiler which had been under experiment November 13th was fired up, and steam raised to one hundred and ten pounds. The fire was active,—what might be called a very clear fire,—and in good condition to make steam freely. It had been kept up sufficiently long to thoroughly heat all the furnace walls. Steam was blowing-off freely from the safety-valve. At a given signal the blow-off cock was opened suddenly, blowing off all the water until the pressure had fallen to zero, and neither steam nor water was escaping from the blow-off cock. In fact, it is believed the boiler was entirely dry. The blow-off cock was then closed, and cold water from a well pumped rapidly into the hot boiler, for it was at all times exposed to the active fire. As the water entered the boiler, the pressure as per gauge rose slowly during an interval of about three minutes, when it is supposed the water-level had reached the more heated portion of the boiler above the bridge-wall of the furnace, for the pressure seemed instantly to increase to one hundred and ten pounds, and steam blew freely from the safety-valve.

This pressure and escape of steam continued for some minutes with no variation, when suddenly an escape of steam was evident from the boiler into the furnace, and upon opening the peep-hole door a jet of water was seen issuing from one of the joints. This leak, in less than a minute, suddenly stopped; then, as the water rose in the boiler, a similar sudden leak and sudden stoppage occurred at the next higher joint; again, at a third one, when, by that time, the water was showing itself at the lower gauge-cock soon afterwards at the second one, when the pump was stopped, at which time the pressure stood at one hundred and ten pounds, steam blowing off freely from the safety-valve. The fire was as active as when the experiment began, and the boiler perfectly tight. This experiment, as before remarked, had been repeated three times previous to the one witnessed by the Committee, and Mr. Harrison's account of the previous experiments, given to your Committee, agreed in every respect with the facts as seen by them.

This is as severe a test as any boiler is ever accidentally caused to sustain, and is, in fact, the one most likely to occur from carelessness. It is also testing practically the favorite theory to account for explosions. During the experiments, the employees of Mr. Harrison seemed quite fearless in their manipulation of the boilers, showing a confidence in their safety truly remarkable. With the exception of the single boiler sealed up and submitted to the extreme pressure of eight hundred and seventy-five pounds to the square inch, all the experiments were tried within the building in which the boilers are made, and any explosion would have resulted in serious loss of property if not of life. Had any ordinary wrought iron boiler, made in the simplest form, and of the best material, been submittted to these same tests, it would have probably been destroyed by any one of them. Regarding the liability to accumulation of sedimentary deposit in this kind of boiler, we can only say that it is asserted by those who have used them the longest, that by occasionally blowing out the water under a full head of steam, then allowing the empty boiler to be moderately heated by the hot furnace, filling up with water and rinsing out, the scale becomes detached and rushes out at the blow-off cock.

The Committee have carefully inspected the manner of making these boilers as practiced by Mr. Harrison, and find the greatest care is taken to insure perfection of workmanship; but, at the same time, it is eminently noteworthy that the peculiarities of the boiler, and its mode of manufacture, are such as to enable a high degree of mechanical excellence to be obtained by mechanical devices, apart from the workman's skill. Thus, in the process of casting, taking as an example a four-ball unit, the four eight-inch spheres united by necks three and a quarter inches diameter, internally, have on each ball two opposite lateral openings, three and a quarter inches diameter, thus making in all, eight openings to four balls. The patterns are all of cast iron, parted lengthwise through the centre of the unit, by a plane at right angles to the lateral openings, these serving as supports to the green sand core which is moulded within the pattern itself, and not in a separate core-box, thus insuring absolute uniformity to the thickness of the metal, and offering a more yielding core to the contracting metal than in the case of dry-sand moulding. The lateral necks which are to serve as joints in combining the units into the boiler structure, are faced off by machinery of the most ingenious kind, so arranged as to insure neat accuracy in the surface, the joints on one side having depressions to match projecting tongues on the other,

these tongues serving with the longitudinal bolts to hold the units in position. One of the most thorough descriptions of this kind of boiler is the report of a paper read by Mr. Zera Colburn before the Institute of Mechanical Engineers in 1864, an abstract of which can be found in *Engineering Facts and Figures*, by A. Betts Brown, for 1864. He shows, that although the tensile strength of cast iron is not so great as wrought iron, yet the spherical form of each unit of the boiler gives it an equivalent strength. He says: "The strength of a hollow sphere to resist internal pressure, is exactly twice that of a hollow cylinder of the same diameter, material and thickness, and it can be shown that even a cast iron sphere, seven feet in diameter and seven-sixteenths of an inch thick, is as strong as the shell of a Cornish boiler of the same dimensions." "The plane in which rupture, if it happen at all, will take place in a hollow sphere, is the largest plane that can be drawn through it, and the metal resisting the strain tending to cause rupture is the whole section of metal bounding the plane." "In a hollow cylinder, the area upon which the greatest pressure tending to cause rupture will be exerted, is that represented by the product of the length into the 'diameter of the cylinder.'" The ends of such a cylinder add nothing to the strength of the cylindrical part, in case of a rupture beginning at the cylindrical part.* The spherical form of each part of this boiler is one of its marked advantages, not only so far as strength is concerned, but as enabling a much larger amount of surface to be exposed to the fire than in any form of combined cylinder. To the spherical form with the curved necks, has been ascribed by the inventor the property, which this boiler is asserted as having to cast its scale when emptied of water, as there is no seeming abutment for the arch of the crystallized scale to spring from. The value of cast iron, so far as durability is concerned, has long been conceded. The purer the iron the more readily does it corrode, while the mixture of even a small amount of carbon increases its ability to resist corrosion. Wrought iron water-pipe under ground soon rusts out. Cast iron, even of the same thickness, remains good after many years' use; in fact, is considered practically to suffer no deterioration. Wrought iron in boilers decays internally—the most rapidly where moisture and air both operate, as in the upper side of mud-drums, while they are often eaten

* The metal effectively resisting the rupture in the cylinder, being only the length of the cylinder. Thus, by comparison, Mr. Colburn arrives at his conclusion as to the relative strength of the two forms.—(See *Engineering Facts and Figures*, 1864, pages 12 and 13.)

through from the outside by trifling leaks, and the constant trickle of water over the surface. Wrought iron boilers are, according to the experiments of Fairbairn and others, so much weakened by the process of riveting &c., as to suffer a deterioration of about forty per cent. The Harrison boiler is made of pieces of as uniform strength as possible, united in a systematic manner. The uniting the units or pieces into mass does not diminish their strength. In case of accident to any part of the boiler the damaged part may be removed, and instead of being repaired, as is done with other wrought iron boilers, new parts may be substituted, just as bricks may be taken out and new ones replaced in a building. The patching of a damaged wrought iron boiler makes it weaker. The renewal of any part of the Harrison boiler gives it its original strength.

The experiments heretofore described, have been conducted to determine the safety and durability of the boiler under unusual and severe usage, or rather to determine whether any danger can result from submitting this kind of boiler to those circumstances which, in ordinary wrought iron boilers, are thought to result in explosions, or great injury to the boiler.

The Committee are impressed with the great utility of the boiler, as one perfectly safe and free from all danger of explosion even when carelessly used. This recommendation alone, in a humanitarian point of view, must strongly commend it to public favor. During the experiments, its steam-making qualities were favorably noticed, and such boilers in actual use as your Committee have had an opportunity to examine, seem to give satisfaction in point of economy; but in the absence of all experiments in this direction, conducted under their immediate supervision, they do not feel qualified to report in figures as to its steam-making efficiency.

Comparing cast iron plates with wrought iron ones of the same thickness, the transmission of heat is known to be in favor of the former; hence the material, if in a safe form, is better adapted to economical steam-making, than wrought iron. Ordinary boiler plate is seldom less than one-fourth of an inch thick, and more commonly three-eighths, particularly for high pressure. The castings used in the experiments for safety, were not over three-eighths of an inch thick, and in one boiler set up in a form adapting it to marine purposes, some of the units were only three-sixteenths of an inch thick, and were worked successfully at one hundred pounds pressure, driving all the machinery in Mr. Harrison's factory in an efficient manner. The principle of en-

largement of the boiler by addition of units, and the fact that it can be constructed in any shape or style, just as various kinds of buildings are constructed of ordinary bricks, places it in the power of the engineer to adapt it in its form to the requirements of each particular case; so that with the known advantage of the use of cast iron, and the unlimited scope in the arrangement of heat-absorbing surface, coupled with the demonstrated fact of safety, your Committee unhesitatingly approve and heartily recommend it to public favor.

Subcommittee appointed to make the examination: Coleman Sellers, Chairman; John Agnew, John F. Frazer, Henry Morton, J. C. Cresson.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, December 19th, 1866.

THE meeting was called to order with the President, Mr. William Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Board of Managers reported their minutes, and that, at their meeting held on the 19th inst., donations were received from the Royal Astronomical Society and the Society of Arts, London, and from the United States Sanitary Commission. They also reported the Treasurer's annual statement for the year 1866.

The Annual Report of the President of the Institute was then read as follows:

PRESIDENT'S REPORT.

In compliance with the third section of Article XIV. of the By-laws of the Institute, the Board of Managers present the following report concerning the operations of the Institute during the year 1866, and its general condition at the present time.

The very extensive improvements noticed in the last report, and which were at that time approaching completion, have now been entirely finished, and have, during a year's use, shown themselves to be of a very satisfactory character.

The lecture-room, as modified, in accordance with the requirements of modern science and the plans adopted by the Board, has been found

exceedingly convenient, both for the meetings of the Institute and for the various courses of lectures which have been delivered before that body.

In the latter respect, however, it has been found wanting, not in convenience and fitness of arrangement, but in adequacy of accommodation for the large audiences drawn together by that increased interest in the Institute and its objects, which has of late been exhibited in so gratifying a degree. In this respect, indeed, the indications seem to point to the propriety of seeking enlarged accommodations and increased facilities for developing the usefulness of this Institution.

With respect to the Library and Reading-room, the improvements above mentioned and before described have been found of great value, facilitating the use of both, by the members of the Institute and strangers visiting the city, as evidenced by the enlarged occupation of the latter, and reference to the former.

The Library has undergone a general re-arrangement, and cataloguing, now nearly completed, by which its usefulness is decidedly increased, as well as by the addition of many new and valuable works.

The number of members of the Institute has been largely increased during the last year, as will be seen from the following statement:

Total number of members in 1865		1433
Elected in 1866	142	
Stockholders added 1866	20	
	162	
Resignations	50	
Deaths	17	67
		95
		1528

The account of the Treasurer, which is herewith submitted, also shows a satisfactory condition of the finances, and we may confidently look for an increased prosperity to the Institute, should the co-operation and support it so well deserves from all interested in the Mechanic Arts be continued and enlarged.

Balance in Treasury, January 1st, 1866		$ 1,002 62
Receipts during the year		14,333 14
		$15,335 76
Payments		12,598 01
Leaving a balance in the Treasury		$ 2,737 75

The indebtedness of the Institute is—

Amount of five per cent. loan	$11,600 00
Interest due thereon	3,863 75
Temporary loan	2,500 00
	$17,963 75

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion reported progress.

No report having been made by the Committee on General Totten's letter, with regard to the establishment of a Government Bureau of Mechanical Examination and Experiment, it was, on motion of Frederick Fraley, Esq.,

Resolved, That this Committee be directed to report at the next meeting, being subject to discharge according to Section 3 of Article X. of the By-laws.

The Special Committee appointed to collect materials with relation to the history of the Institute, reported progress.

The paper announced for the evening (On Steam Boilers, by Joseph Harrison, Jr.) was then read. (An abstract of this paper will be found in this *Journal*, beginning with page 131 of the present number.)

At the conclusion of Mr. Harrison's paper, the President expressed to Mr. Harrison the thanks of the Institute; after which the Judges of Election reported the result of the ballot as follows:

Officers, Managers and Auditors of the Franklin Institute, elected January 16th, 1867: President, J. Vaughan Merrick; Vice-Presidents, (for three years,) Coleman Sellers; (for one year,) to fill a vacancy, George Erety; Secretary, Henry Morton; Treasurer, Frederick Fraley; Managers, (for one year,) to fill a vacancy, Robert E. Rogers, M.D.; (for two years,) to fill a vacancy, Robert Briggs; (for three years,) William Sellers, William J. Horstmann, Henry Cartwright, Samuel Hart, B. H. Moore, H. G. Morris, W. B. Bement, E. Y. Townsend; Auditor, James H. Cresson.

The Ex-President, Mr. William Sellers, then inducted to the chair the new President, Mr. J. V. Merrick.

Some remarks on the quadrature of the circle by various new plans were then made by Mr. John May, and a paper on the manufacture of bricks, ancient and modern, was read by Mr. Bond.

It was then moved by Mr. Coleman Sellers, that on account of the lateness of the hour, the reading of the Secretary's Report be dispensed with, which motion was duly carried, and there being no deferred or new business for consideration, the meeting was, on motion, adjourned.

HENRY MORTON, *Resident Secretary.*

A COMPARISON *of some of the Meteorological Phenomena of* DECEMBER, 1866, *with those of* DECEMBER, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	December, 1866.	December, 1865.	December, for 16 years.
Thermometer—Highest—degree	61·00	63·00	71·00
" date	8th.	27th.	2d, '59.
Warmest day—mean	57·00	55·33	62·80
" " date	8th.	4th.	2d, '59.
Lowest—degree	6·00	17·00	4·50
" date	21st.	15th.	19th, '56.
Coldest day—mean	15·33	21·67	11·00
" " date	21st.	15th.	18th, '56.
Mean daily oscillation	12·10	11·23	12·11
" " range	6·83	6·85	6·50
Means at 7 A. M.	31·58	35·34	32·00
" 2 P. M.	37·18	40·82	39·18
" 9 P. M.	34·19	36·95	34·80
" for the month	34·32	37·70	35·32
Barometer—Highest—inches	.....	30·424	30·678
" date	.....	23d.	18th, '56.
Greatest mean daily pressure	.....	30·399	30·611
" " " date	.....	23d.	18th, '56.
Lowest—inches	.....	29·408	28·946
" date	.....	21st.	9th, '55.
Least mean daily pressure	.....	29·535	29·175
" " " date	.....	1st.	9th, '54.
Mean daily range	.....	0·206	0·215
Means at 7 A. M	.....	29·945	29·950
" 2 P. M	.....	29·899	29·907
" 9 P. M	.....	29·946	29·936
" for the month	.....	29·930	29·931
Force of Vapor—Greatest—inches	0·472	0·509	0·551
" date	8th.	27th.	2d, '59.
Least—inches	·042	·068	·025
" date	20th.	22d.	18th, '56.
Means at 7 A. M	·152	·177	·146
" 2 P. M	·153	·180	·167
" 9 P. M	·165	·182	·158
" for the month	·157	·180	·157
Relative Humidity—Greatest—per cent	96·0	97·0	100·0
" date	16th.	27th.	Often.
Least—per cent	35·0	33·0	23·0
" date	9th.	5th.	15th, '61.
Means at 7 A. M.	79·4	80·7	77·5
" 2 P. M.	64·5	64·3	65·2
" 9 P. M.	76·9	76·7	75·2
" for the month	73·6	73·9	72·6
Clouds—Number of clear days*	14·	6·	8·8
" cloudy days	17·	25·	22·2
Means of sky covered at 7 A. M	46·4 per ct	74·8 per ct	63·6 per ct
" " " 2 P. M	56·4	61·6	63·2
" " " 9 P. M	42·6	60·0	48·7
" " for the month	48·5	65·5	58·5
Rain and melted snow—Amount—inches	3·522	5·677	3·822
No. of days on which rain or snow fell	9·	12·	10·5
Prevailing Winds—Times in 1000	N78°16′W·351	N68°27′W·239	N63°53′W·273

* Sky one-third or less covered at the hours of observation.